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A. H. PURDUE, State Geologist

BULLETIN 17

THE WATER POWERS OF TENNESSEE

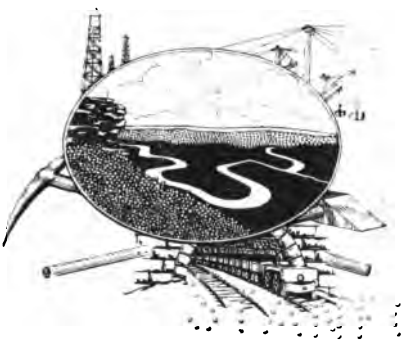
By J. A. SWITZER

Including

A REPORT ON DOE RIVER

In cooperation with the U. S. Geological Survey

By A. H. HORTON



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PUBLISHED MARCH, 1914

BAIRD-WARD PRINTING CO.
NASHVILLE, TENN.

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PREFATORY STATEMENT

This bulletin is the result of an honest attempt to comply with the spirit, and as far as possible with the letter of Senate Joint Resolution No. 62 of the Fifty-seventh General Assembly of the State of Tennessee. The work of preparing it was intrusted to J. A. Switzer, Professor of Hydraulic Engineering, University of Tennessee, because his training as a hydraulic engineer, and the study he had already made of water power conditions in the State, especially fitted him for it. As required by the resolution, the report was ready for the Fifty-eighth General Assembly, but provision was not made for its publication in time to be used by that body.

It must be understood that in the portions of the report dealing with stream flow, the engineering data given are only of a preliminary nature for all of the streams mentioned, with the exception of the Doe River; and the records even in the case of this river, cover a period that is much too brief for complete knowledge of its water power possibilities. The full scope of the bulletin will be understood by reference to the Table of Contents.

The very great importance of the water powers of Tennessee will sooner or later result in legislation relating thereto. Indeed, the senate joint resolution referred to, plainly contemplated legislation of this character at an early date. With that in view, Professor Switzer has brought together the water power laws of several states of the Union, and of Canada, Italy, France, and Switzerland, that those interested in water power legislation may, in framing it, conveniently take advantage of the experience of other states and countries.

In the framing of laws relating to the State's water power resources, as in all legislation which seeks to control a public utility, two things must be kept in mind; namely, the rights of the public, for which the utility exists, and the rights of capital, without which it can not be developed and thereby rendered available. Unless the public is given needed protection, its interests will suffer; unless capital is promised not only fair protection but also the probability of reasonable returns, it will not invest. No water

power legislation will be just that on the one hand fails to give the people the advantage of cheap light and power, or on the other, inflicts capital with such stringent regulations as to prohibit, or even unduly delay, the development of the enormous hydro-electric energy that is now only in part utilized. Between these extremes there is some middle policy, which if adopted, will bring results of immense benefit to the State. These considerations have had control in the preparation of those parts of the bulletin which deal with the economic aspect of the subject.

The importance of the water power of Tennessee, developed and potential, can not be too strongly impressed upon the public. In the coming years its value will rank with those of agriculture and mining. It will light our houses, churn our butter, launder our clothes, run our shops, drive our autos, move our trains, pump our water, smelt our ores, heat our homes, and probably do other things now thought of only by the far-sighted electrician.

A. H. PURDUE,
State Geologist.

Nashville, Tenn.
March 20, 1914.

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THE WATER POWERS OF TENNESSEE

By J. A. Switzer

INTRODUCTION.

The 57th General Assembly of Tennessee adopted the following resolution, placing upon the State Geologist an obligation in response to which this bulletin is written:*

> Be it resolved, by the Senate of the 57th General Assembly, the House concurring, that the State Geologist be directed to make a full and careful investigation of the water power resources of the State, and report to the next General Assembly what suitable sites are remaining unappropriated by individuals and corporations; what sites have been so appropriated; what is the value of the earning capacity of the latter class; what is the value of those sites remaining, and what would be the probable cost of utilizing them, and what would be their probable earning capacity, which report he shall submit to the next General Assembly, together with a plan for utilizing and enjoying the same. Adopted July 5th, 1911. Signed by N. Baxter, Jr., Speaker of Senate, and A. M. Leach, Speaker of House. Approved July 7th, 1911, by Gov. B. W. Hooper.

In the passage of this resolution the General Assembly saw fit to strike out the clause making an appropriation of $15,000.00 or the purposes of the resolution. In the absence of any appropriation whatsoever, the Survey decided to spend a sum of about $500.00 wherewith to do its utmost toward complying with the requirement laid upon it. A similar act passed some years ago by the State of New York, carried an appropriation of $35,000.00. Commenting upon this, the eminent engineer, John R. Freeman, whom the State employed to make the investigation, said: "The appropriation was insufficient and the time too short. The entire appropriation and the entire time

*Senate Joint Resolutions No. 62. (Bacon.)

allowed are smaller than I have sometimes found it necessary to expend on the surveys and studies for a single project of water power development."

It is of interest to note that a period of seven years has been consumed, and a sum of money considerably in excess of $100,000 has been spent by the State of New York in its effort to secure precisely the information called for by the above mentioned joint resolution, which, as it finally passed, carried no appropriation at all.

The water power resources of the State of New York are not larger in the aggregate, nor are they of intrinsically greater economic importance, than are those of Tennessee.

THE ECONOMIC ASPECTS OF WATER POWER

One of the marked characteristics of the present decade in the life of America is the newly awakened realization throughout the country of the enormous value of our latent water powers. We stand today at the beginning of the Age of Conservation. In common with her sister states, Tennessee faces the pressing necessity of determining and declaring what shall be her attitude toward her water power resources. The citizenship at large does not realize how important is the subject, nor how pressing is the need for prompt action.

The importance of water power has become really great only within the last twenty years. While it is true that the power of falling water has been utilized since prehistoric days in a small way, the development and utilization of any large water powers is a wholly new thing. It necessarily awaited the inventions and discoveries in electricity, whereby power generated at the site of the water-fall might be transmitted to a distance, there to turn the wheels of industry, to move the cars, to light the homes of men.

It is the hydro-electric industry which is new, and within twenty years it has grown to colossal proportions. A generation ago there existed perhaps no reason why the riparian owners of the streams should not be the sole owners of the water powers afforded by such streams. Now, we find that very suddenly water power has acquired the characteristics of a public utility, and as such the State must deal with it.

There are two commanding facts regarding the hydro-electric industry which give to it an importance of grave national extent. Of these the first is the relation it bears to our coal supply, and the second is the ease with which it yields itself to monopolistic control. These two are so closely interrelated that they can well be considered together.

The rapidity with which the world is consuming its coal supply is not realized except by those who have devoted special study to the subject. It is characteristic of the common thought to assume that what always has been always will be. Coal has always been

available and the supply is still plentiful. Why bother about that time, remote in the future, when it will be gone?

That time is not remote in the future. Two hundred years is but a brief period in the life of a nation, and two hundred years hence the depletion of our easily accessible coal deposits will be all but complete. It is a matter of vital concern to us as a nation that we conserve our coal supply by every possible means—that we put off the day when coal may no longer be used as a source of power.

Could all the available water power within the borders of the United States be harnessed tomorrow, the ultimate exhaustion of coal would be postponed though not prevented. According to Mr. Herbert Knox Smith, until recently United States Commissioner of Corporations, the total stationary power now used in the United States—steam, water, and gas,—is probably over 30,000,000 horse power. The total commercial motive power—railroads and steam boats—probably exceeds 1,000,000 horse power; while if we take account of the quantity of coal used for heating and domestic purposes, and express it in terms of the equivalent horse power which such quantity of coal would produce, we may say that the present day total demand for power in this country alone approximates 33,000,000 horse power. Our total developed water power is about 6,000,000 horse power, and that now capable of development on a present economical basis probably does not exceed 25,000,000 horse power. The United States Geological Survey has estimated the "minimum potential" water power of the country at 32,083,000 horse power, and the "assumed maximum" at 61,678,000 horsepower, both figures, excluding storage possibilities.

The ultimate possibilities for water power development—that is the total amount that is conceivably susceptible of development by the aid of complete storage of flood waters, is at present impossible of computation; and different authorities who have attempted such computations arrive at results very wide apart. Whether the ultimate possible water power development be double or quadruple the above amount, is not material to the present discussion. For enough has been said to make it evident that the world needs to have its water power resources put to work, and that, too, as promptly as considerations of the larger welfare will permit.

Enormous as the present demand of society for power has been

shown to be, the rate at which that demand grows year by year is so very great that within forty years—it may be within twenty years—the inevitable upward movement in the price of power and the price of coal will begin. And when it does begin, it will proceed at an accelerated rate, in spite of all that the states and the United States may do.

While the average citizen proceeds with his accustomed round of duties and thoughts, wholly oblivious of all such considerations, there are men who are keenly alive to the situation. They realize that ownership of water power, today quite desirable, will tomorrow be most enviable. When a coal mine has given up its coal it has become worthless. Water power is perpetual. The profit from a ton of coal may be taken by its owner but once. The profit from a falling stream may be taken this year, and then again next year, and the next and the next. And while a coal mine becomes intrinsically less valuable every year, a water power intrinsically becomes more valuable as the depletion of the coal supply progresses.

Considerations such as these constitute potent reasons for a desire to own and control the large water powers of the country. Another reason for such a desire resides in the peculiar nature of water power, whereby it lends itself naturally to monopolistic control. Power may now be transmitted electrically over long distances with good economy. The street cars of Nashville are now operated with power generated at Parksville, 160 miles distant. The Southern Power Company has transmission lines in the Carolinas aggregating over 1380 miles in length. A company which owns a network of transmission lines and a number of water power developments within the territory which it covers, can so use its power as to effect economies not otherwise obtainable, and thereby secure much larger returns upon its investment than would be possible if the various power stations were not inter-connected. Indeed, for the full development and utilization of large water-powers with maximum economy, such inter-connection is essential. For both of these reasons centralization of ownership and control of large water powers in the United States has already proceeded to such a length as to have created grave dangers to the welfare of the nation, and the future menace of a monopoly of the most burdensome character is now recognized as being imminent.

The attention of the people of Tennessee is called to the report

of the late United States Commissioner of Corporations on "Water power Developments in the United States," submitted to the President on March 14th, 1912. The report is the outcome of a thorough investigation of facts, and neither these facts, nor the conclusions to which they inevitably point, can be evaded or explained away.

In his report the Commissioner points out that the most desirable water power sites in the country have now passed into the hands of private owners or corporations. That the concentration of ownership and management involves not only the water-powers, but a very large number of public utilities as well—street car systems and gas and electric supply companies all over the country. By interlocking directorates, or by majority holdings of stock, the control or influence of a small group of men extends throughout the country. Thus we read, for instance, "the influence of the General Electric Company in municipal public-service corporations is not by any means confined to those communities that have water power. It, or its subsidiaries, has acquired control of, or an interest in, the public-service corporations of numerous cities where there is no water power connection, and it is affiliated with still others by virtue of common directors. Perhaps the chief significance of the wide General Electric influence in municipal public-service corporations that have no connection with water power lies in the fact that it emphasizes the tendency of large interests not only to acquire the water powers in various sections, but at the same time to acquire the control of those public-service corporations that are naturally the best customers for water power. Broadly speaking, hydro-electric developments, electric railways and electric-lighting plants fall within that group of enterprises commonly known as the electrical industries, and quite naturally an interest in one branch involves an interest in other branches. Some of the largest municipal public-service corporations in the country are subject to General Electric control or influence. The American Gas & Electric Company is one of the most prominent examples. It is controlled by the General Electric Company through the ownership of a majority of its stock by the Electric Bond & Share Company. The American Gas & Electric group of concerns includes 13 lighting corporations operating in seven states."

The General Electric Company, whose legitimate business is

the manufacture and sale of electrical machinery, through its subsidiary companies, controls public utilities in 18 states. It owns or controls undeveloped water powers aggregating 641,600 horse power, and water powers developed or in process of construction having a total capacity of 939,115 horse power—a total of over a million and a half horse power. This company with nine others "control or have under their influence more than 60 per cent of all the commercial water power developed and under construction in the United States." "The five largest groups of holders of developed water power in the United States control more than 50 per cent of all the commercial power developed and under construction in the country, besides having more than 1,200,000 horse power undeveloped." "Seventeen corporations and groups of corporations control about 70 per cent of all the commercial water power in the United States."*

Although written so recently, the report has little to say concerning the condition in Tennessee. Yet it will be shown in detail later in this bulletin that since January 1st, 1912, events in Tennessee have moved rapidly, and in anticipation of the full details, it may be said that here too the best water power sites are now passing into the hands of private companies or corporations.

---

*Water Power Development in the United States. Herbert Knox Smith, U. S. Commissioner of Corporations.

THE RELATIONS OF THE STATE TO ITS WATER POWER RESOURCES

The Survey believes that there is urgent need of constructive legislation which shall declare the water powers of the State to be a public utility, and which shall assert the ownership of the State therein.

In support of the constitutionality of such action, we cite the following excerpts from the Report of Hon. Knute Nelson, on behalf of the U. S. Senate Committee on Commerce. (Senate report 585, 60th Congress, 1st session).

> "The title to the water of a navigable stream within the borders of a state is not in the Federal Government, but in the State; and the title to the banks and bed of the stream, after the Federal Government has parted with its riparian lands, is either in the state or the riparian owner, or both, according to the laws of the respective states. These principles have been laid down and applied by the Supreme Court of the United States in the following, among other cases, and is the settled law of the land, to-wit: Martin v. Wadell, 16 Pet., 367; Pollard v. Hagen, 3 How., 212; Goodtitle v. Kibbe, 9 How., 471; Barney v. Keokuk, 94. U. S., 324; St. Louis v. Myers, 113 U. S., 566; Packer v. Bird, 137 U. S., 661; Hadrin v. Jordan, 140 U. S., 371; Kaukauna Water Power Company v. Green Bay and Mississippi Canal Company, 142 U. S., 254; Shively v. Bowlby, 152 U. S., 1; Water Power Company v. Water Commissioners, 168 U. S., 349; Kean v. Calumet Canal Company 190 U. S., 452; United States v. The Chandler Dunbar Water Power Company, U. S. Supreme Court, April 20, 1908.
>
> "The use of water in such a stream is a matter of state regulation and state control. In many of the states the

common law rule, as defined in the following language of Chancellor Kent, prevails, to wit:

"Every proprietor of lands on the bank of a river has naturally an equal right to the use of the water which flows in the stream adjacent to his lands, as it was wont to run (*currere solebat*) without diminution or alteration. No proprietor has a right to use the water to the prejudice of other proprietors above or below him, unless he has a prior right to divert it, or a title to some exclusive enjoyment. He has no property in the water itself, but a simple usufruct while it passes along. *Aqua currit et ut currere solebat* is the language of the law. Though he may use the water while it runs over his land as an incident to the land, he cannot unreasonably detain it or give it another direction, and he must return it to its ordinary channel when it leaves his estate.

"The rule of riparian ownership as to grants of land bordering on a navigable stream is diverse in the various states. Some states hold that the grant extends only to the high-water mark; other states hold that it extends to low-water mark, while another class of states—and perhaps the most numerous—hold that the grant extends to the middle of the stream, subject to the public easement in the water of the stream. But whatever the law may be in this respect as to the effect of the grant, it only relates to the proprietorship in the banks and bed of the stream and *not to the ownership of the water in the stream.*

"In those states which hold that the title of the riparian owner only extends to the high or low water mark, the title to the bed of the stream is deemed to be in the state, and whenever the title to the bed of the stream is in the riparian owner or in the state, in either case the general title to the water of the stream is deemed to be in the state, but it holds it not absolutely, but *in trust for all lawful public uses.* The state's interest in such a stream is akin to that of a riparian owner, though more comprehensive and general in its nature, and does not exist in hostility to or diminution of the rights of the riparian owner. Rossmiller v. State, 114 Wis., 169; People's Ice Co. v. Davenport, 149 Mass., 322; Brown v. Cunningham, 82 Iowa, 512·

Braston v. Rockport Ice Co., 77 Maine, 100; Martin et al. v. Waddell, 16 Peters, 367.

"From the foregoing it will appear that there are three different parties who are interested in the waters of a navigable stream: (1) the United States, (2) the state in which the stream is located, (3) the riparian owner. The interest of the United States is derived from and rests upon that paragraph of the constitution which gives Congress the power to regulate interstate commerce, and this power only extends to the extent of conserving the navigability of the stream. Beyond that the Federal Government has no interest or property in the stream.

"The interest of the state in the stream is derived from its sovereignty, and it holds its property in the stream in trust for all public uses, but in subrogation to the rights of the Federal Government as to navigation and of the riparian owner. The right to the use of the waters of a stream for any lawful purpose, outside of the rights of navigation, belongs wholly to the state and the riparian owner, Martin et al. v. Waddell, 16 Peters, 367."

ARGUMENTS FOR WATER POWER LEGISLATION

Such legislation as we recommend would be in line with that of the most progressive of the states. The water powers of Tennessee are among her most precious assets, the perpetual ownership of which, if it reside in the State, will do much to insure her future welfare and prosperity. And if, on the other hand, the ownership be allowed to pass by default into the hands of corporations, then the menace to our free institutions which now looms so large in our national life will be incalculably heightened.

It being now everywhere recognized that the conservation of water power resources is best accomplished by the prompt development of those water powers, there are those who argue that therefore the most enlightened policy for the State to pursue is one of inaction. "Let us do nothing," they say, "that will hinder foreign capital from coming into the State and developing our water powers." Foreign capital, they tell us, is a timid creature, and should the State change its policy of giving away water power privileges absolutely for nothing, foreign capital will be frightened away and will seek investment elsewhere.

The argument is not sound. Nor is it always disinterested. The policy of a reasonable State control of water power development, accompanied by the imposition of a reasonable rental charge for the use of water, does not deter water power development. This fact is well illustrated by the situation at Niagara Falls. Here water power is developed on both sides of the river. On the American side the present development amounts approximately to 262,000 horse power, and on the Canadian side to 238,000. The ultimate development permissible at Niagara under the treaty of 1910 with Great Britain will be, on the American side about 460,000 and on the Canadian side about 840,000 horse power. The companies on the American side of the river pay no rentals whatever, the privilege of utilizing this great natural resource having been given away absolutely free. The power companies on the Canadian side pay to the Province of Ontario an annual

rental for the privilege of generating power from the falls. The charges made by the Ontario Government are $15,000 per annum for a franchise involving as much as 10,000 horse power; $1 per annum for each electrical horse power generated and used over 10,000 horse power and up to 20,000 horse power; $0.75 per horse power for all power generated and used over 20,000 and up to 30,000 horse power; and $0.50 for each electrical horse power generated and used over 30,000 horse power. From these rentals the receipts in 1910 were slightly less than $133,000. And when the ultimate development is realized, the Province of Ontario will enjoy an annual revenue from this single water power of about $430,000. In spite of this charge the Canadian power companies are reasonbly prosperous. Commenting on this situation, the New York Water Supply Commission says: "We have only to look across our northern border to the Dominion of Canada to see how our mistakes in allowing private interests to acquire natural resources have been avoided by the statesmanship of the Dominion government." New York, it may be remarked, having recognized its mistake, has tardily changed all this and has now ceased to be a happy hunting ground of "the few intent upon amassing fortunes and creating monopolies," at least in so far as the further acquisition of valuable water powers is concerned, without making some sort of adequate return to the people therefor.

Even if it were true that the adoption of a wise policy of conservation by the State would for the time being check the flow of foreign capital into our territory, every dictate of broad statesmanship would nevertheless incite us to take such action. When capital invests in a foreign territory what disposition does it make of the profit upon such investment? Does the profit enrich the foreign territory, or does it return to the home of the investor? It is argued that if foreign capital comes in and develops our latent water powers, it must find a market for such power locally, or create one, and hence it creates employment which did not exist before and so adds to our prosperity.

There are two reasons why this argument is specious. First, the market for the power need not necessarily be found locally. Power developed on the Clinch River in Tennessee might very well find a market in Cincinnati, Ohio. Of what profit would it be to the people of Tennessee if capital from Pennsylvania build power houses within our borders costing $20,000,000, pay to the treasury

of Tennessee the trivial incorporation tax on a relatively small capitalization, and transmit and sell the power outside of our borders? Second, what comfort is it to a man who, being met on the highway by a polite bandit, is assured that if he give up his wallet without protest, he will be returned ten cents for carfare home and fifty cents to buy his supper? The State is entitled to more than the tax on the improvements; it is entitled to the franchise value of the water power itself.

Suppose that a given water power can be developed at such an outlay that, allowing duly for interest on investment, depreciation, attendance and upkeep, the power actually costs $10.00 per horse power per year to generate. Who can point to the private corporation which, owning the plant, would be content to add to this cost a reasonable profit, and offer the power for sale at, we will say, $12.00? Or even $13.00? No such reasonable prices would be made. The market price of power, in the absence of State regulation, is fixed by the cost of competing steam power, and the power of our hypothetical hydro-electric plant would be sold at the maximum price which "the traffic would bear." And the margin of profit would benefit Tennessee not one whit.

What course shall the State pursue with reference to its water powers? In this matter the State of Tennessee is not the pioneer, and she may well benefit by the experiences of many of the other states. Notably the states of New York, Maine, Oregon, Minnesota, Wisconsin, Pennsylvania, and California have preceded Tennessee in grappling with the problem of State control of water and water power resources. Further on we shall give a resume of the course which has been pursued by several of these States as well as by certain foreign countries, and in the Appendix are reproduced in full the laws of some of them.

THE WATER POWER QUESTION IN NEW YORK

Apparently the State of New York stands first in respect to the thoroughness and sanity with which it has proceeded in dealing with the question, and a review somewhat in detail of the experience of that state will prove of value in the present discussion. Quoting from the reports of the New York Water Supply Commission and the New York State Conservation Commission, we find as follows:

> "The policy of the State with regard to the conservation and development of its water powers has been of gradual growth, although each step has led in the same general direction.
>
> "Following an agitation of more than ten years, during which the increasing importance of the water powers of the State constantly obtained greater recognition, the Legislature in 1902 created the Water Storage Commission, consisting of five citizens appointed by the Governor to act with the Attorney-General, the State Engineer and Surveyor, the Superintendent of Public Works, and the Forest, Fish and Game Commissioner, to investgate the causes of floods and to make recommendations for their prevention. This Commission found that the loss from floods in the State during 1902 had exceeded $3,000,000. Its studies of the various streams led it to call attention forcibly to the extremely valuable possibilities of water power development, and in the report which it made to the Legislature in 1903 it said:
>
> We believe that State supervision and control is the only safe method of intelligently initiating, constructing and maintaining an adequate system of river improvement in this State. Such State supervision and control, by a commission of recognized competence and character, would not only secure the scientific treatment of such stream as a whole, but the safe and economical execution of the various component parts of a comprehensive system of river improvement in the order of their relative urgency and importance. Legislation providing for such a system of river regulation is in our opinion a great and urgent public necessity."

The Commission further recommended that the work of river improvement should be entrusted to a permanent commission and that its cost should be borne entirely by the property benefited.

This recommendation was adopted by the Legislature, which act committed the State to the policy of State control. In 1907 the Legislature took a further step by establishing the principle that new grants of water power rights should be made only upon the basis of an annual payment to the State for the privilege granted, the amount of such payments to be readjusted at specified terms.

Still another and more important step was taken by the Legislature of 1907 by the passage of the law commonly known as the "Fuller Act" (Chapter 569 of the Laws of 1907). This act directed the State Water Supply Commission to collect information relating to the water powers of the State, devise a general plan for their progressive development and report a draft of a referendum bill for a general law to carry its recommendations into effect. In the preparation of the bill which the Commission was directed to draft in order to carry out its recommendations, it was required to include a financial plan providing for the issue of State bonds to pay the cost of water power development, and for an annual tax sufficient to pay the interest and sinking fund charges thereon. The bill also provided that "the rate of charge for the use of the water horse power under contract for sale shall be based upon the aggregate cost of the development * * * and such rate of charge shall be so adjusted that it will produce a net revenue sufficient to pay, in addition to all costs of superintendence, maintenance and depreciation, the interest upon the bonds as the same shall become due and the principal of said bonds at their maturity."

Thus at the beginning of 1908 the Legislature had outlined a State policy with regard to water powers, the principal points of which included State control, the payment of compensation for new grants, the storage of water by the State at public expense and the sale or lease of the right to use the water so stored upon terms which would reimburse the State for its outlay, and the progressive development by this method of all streams capable of yielding additional water power.

In pursuance of the policy outlined in the Fuller Act, the State has expended upward of $100,000 in ascertaining the extent and

value of its undeveloped water power resources and in making the detailed surveys and estimates required by the act.

In recommending the subject to the Legislature of 1909, Governor Hughes in his annual message expressed the opinion that the following principles should be accepted:

> "(1) That the flow of water in our rivers should be regulated and our water powers developed to the fullest extent that may be practicable. This is essential to prevent unnecessary damage from floods and to ensure our industrial progress and the future prosperity of our people.
>
> "(2) That with respect to streams having their headwaters within the boundaries of the forest parks, all plans of regulation or power development should be executed only by the State, and all reservoirs and their appurtenances and the impounded waters should be the property of the State and under exclusive State control, and not be permitted to pass into private hands. Any such plan should embrace all necessary safeguards to ensure the proper protection of the forests.
>
> "(3) That with respect to any other streams flowing through any other public park or reservation of the State, such plans should likewise be executed by the State, and it should retain exclusive ownership and control in order adequately to safeguard the State's interests.
>
> "(4) That further, as it is of great public importance that the waterpowers of the State should be developed in a comprehensive manner, and that these natural sources of industrial energy should not become the subject of an injurious private control, such development should be undertaken by the State whenever such action appears to be feasible and for the general interest.
>
> "(5) That in any case of State development of water power, provision should be made for the granting of such rights as may be proper to use the power so developed upon equitable terms and conditions.
>
> "(6) That the State should not undertake any plan of regulation or water-power development save upon a basis which would make its investment a fair and reasonable one from the public standpoint by virtue of practicable measures for ensuring such a return upon the State's outlay as would be equitable in the particular circumstances.
>
> "(7) That any amendment of the Constitution at this time for the purpose of permitting any portion of the forest preserve to be used for any such purpose should, by its terms, or by appropriate reference, suitably define the property within the preserve which is to be used and the manner of its use. No amendment and no plan of development should meet with any favor which, after the most rigid scrutiny, does not afford absolute assurance that in no way will the public interest in the forests be parted with or jeopardized."

In accordance with the requirement of the Fuller Act and the recommendations of the Governor, the Commission with its last

annual report submitted a draft of a bill for a general law. This draft was considered by the Legislature, hearings were given upon it, its provisions were thoroughly discussed and changes were made in certain particulars. In its final perfected form it provided a scheme of general conservation and development of water powers by the State, which in brief outline was as follows:

> "Any person may petition the State, through the State Water Supply Commission, to construct a storage reservoir. The petition must show that the reservoir will produce an annual net revenue to the State by the lease of the water stored or of the power generated thereby or by assessment for benefits resulting therefrom. The petitioner must guarantee to the State a gross revenue sufficient to pay operating expenses and interest and sinking fund charges upon the cost of the reservoir.
>
> "If the Commission has not already prepared plans covering the project, it must proceed to prepare them, and if conflicting petitions are filed, it may co-ordinate them. Within thirty days after the filing of a petition or the completion of plans it must accept or reject the petition and give its reasons therefor.
>
> "If the Commission approves a petition, it must lay it before the Governor, with the plans and estimates relating to it, and if the Governor approves it, he must within thirty days direct the Commission to proceed to build the reservoir.
>
> "The Commission without petition may present to the Governor a reservoir project which will yield a net revenue to the state.
>
> "Real estate required for the execution of the work may be appropriated upon notice when needed, and if compensation cannot be agreed upon with the owner by the Commission, the Court of Claims is authorized to make an award which the Comptroller is directed to pay.
>
> "The work of construction must be done under contract approved by the Governor.
>
> "The Commission is authorized to make and enforce rules for the maintenance and operation of storage reservoirs.
>
> "The Commission may lease for terms of not more than fifty years the right to use water from any State storage

reservoir, or the power developed therefrom, for a sum which shall not be less than the interest, sinking fund and operating charges, and the rental shall be a tax upon the property benefited.

"In consideration of benefits to be conferred, the Commission may enter into a contract for a reasonable consideration with any person or corporation, municipal or otherwise, and the sum so agreed upon shall be a tax upon the property benefited.

"When no contract exists, the Commission is directed upon the completion of the reservoir, and at five year intervals thereafter, to assess the value of the yearly benefit upon the property and the municipalities benefited, and the assessment shall be a tax upon the property or the municipality. Hearings must be given by the Commission upon assessments, and its decisions may be reviewed in the manner provided by the Tax Law.

"All moneys received must be paid into the treasury to the credit of a fund to be known as the State Water Storage Fund, from which appropriations may be made for paying the cost of maintaining and operating reservoirs, for additions to the sinking fund to retire water storage bonds, for building other storage reservoirs and for deposit to the general credit of the State.

"Bonds limited in amount to $20,000,000, in interest to 4 per cent., and in term to fifty years, shall be issued by the State to provide funds for building storage reservoirs as money may be required for payments under contracts. Not more than $2,000,000 may be issued in the year after the act takes effect, and thereafter the bonds shall be sold in lots of not more than $1,000,000. For each $1,000,000 of bonds outstanding a State tax of twelve one-thousandths of a mill is imposed for the payment of the interest and sinking fund charges until the sinking fund shall equal the principal of the bonds, after which time the tax shall be reduced to an amount equal to the interest alone.

"It is expressly declared that nothing in the act shall be deemed to confirm any right or privilege claimed, or to impair any right or power now belonging to the State. The Commission, for the State, is empowered to revoke

any use of real estate for private purposes under the authority of or by sufferance of the State in cases where the State can revoke.

"The bill, when approved by the Legislature and the Governor, must be submitted to the people for their approval in the general election of 1911, and will take effect only when approved by a majoriy of the voters who vote upon it."

In 1909 the Legislature still further increased the powers of the Commission to cover cases of water power development where the expense should be borne by local or private parties interested.

In its report for 1910, the Water Supply Commission summarizes as fol ows the reasons why State control of water power development is essential:

"Development by the State ensures the fullest possible utilization of the power possibilities of each stream, whereas development by uncontrolled private enterprise often involves waste of resources. Private capital, seeking the greatest possible immediate return on the investment, naturally confines its attention to the most concentrated portion of a given fall. The less precipitous portions of the fall above and below, involving a large unit outlay in development, are consequently apt to be neglected, and in too many cases permanently wasted, because no other enterprise is likely to undertake their development afterward, even if the right of the company already on the spot would permit this to be done. On the other hand, the State, with its greater power and scope, and with financial resources enabling it to defer the return on its investment, could undertake the construction of the more extensive works necessary to develop the full extent of the fall in the supposed case. Without amplifying the point, it should be clear that the State is the only authority with sufficient power to insure the complete development of each and every stream so that every foot-pound of energy represented by its falling waters may be given up when necessary to the service of man.

"The financial strength of the State enables it to undertake the large outlay involved in reservoir construction

at much lower rates of interest than any private corporation, individual or association could hope to command. While credit is not money in the real sense, it is an important factor in financial enterprises, and in proportion as the credit of the State is better than the credit of private enterprises, the State is better equipped to develop its own resources. It would be practically impossible for a person or corporation to raise, without the use of bonds based on its credit, a sum sufficient to build the great reservoirs needed for stream control. An individual or corporation would be obliged to issue a 5 per cent. or possibly a 6 per cent. bond, and if a 5 per cent., to put it on the market at 85 or 90 per cent. of its par value. On the other hand the State can float its 3 or 3½ per cent. bonds at par. The 6 per cent. which a private enterprise would have to pay as the fixed interest charge upon its original investment would pay the 3½ per cent. interest on the State investment and in addition provide a sinking fund that would retire the bond issue in less than twenty-five years. Such an advantage in favor of State construction and ownership cannot be overlooked.

"Some of this very saving probably would and certainly should be used, in case the State does the work, to insure that degree of care in the planning and construction of dams, reservoirs and appurtenant works which is necessary to render these structures worthy of the State from an esthetic point of view. At any rate this object must be attained. Only under State control can the people of the State be absolutely safeguarded in their right to have the natural beauty of their streams and lakes maintained at the highest degree consistent with the necessary and proper measures for regulation of flow and utilization of fall.

"Even if private enterprise were in as strong a financial position as is the State, it has not the necessary authority to undertake river regulation on a large scale. Aside from the fact that under the laws of the State the power of eminent domain cannot be granted for this purpose, the proper construction of a great controlling reservoir is beyond the scope of any one individual, company or even association. Moreover, as all the developments on the stream receive the

benefit of control, mutual action is a necessity. But mutual action and the distribution of costs and benefits in such a work has been shown by experience to be peculiarly difficult to arrange. Since individual development must of necessity be selfish in its purpose and limited in its extent, constant friction is likely to prevail not only between the different developments on a given stream but between their collective interests and that of the public. Under such conditions the incidental value of stream regulation for other public purposes, such as the prevention of floods, the dilution of sewage, the improvement of navigation and the protection of municipal water supplies, would inevitably fail to receive just and proper consideration.

"State control means the careful utilization of each stream under a pre-established plan by which growing needs may be progressively met without impairing the eventual completeness of the development. With such a predetermined plan the State will be able to take into consideration many other factors in its public economy. With the possible future storage needs of a water shed in mind, the State can easily prevent the location of railroads, buildings and other structures at points where in the future they would have to be removed at great expense and trouble to make way for storage reservoirs.

"In addition to the reasons for State control above enumerated, there is the need of supervision over the construction of dams to ensure their safety. No one will doubt that under State construction every precaution to secure the stability and safety of these structures will be taken. There are too many cases where private enterprise, with its eye on the immediate outlay, is tempted to save expense by the use of methods and materials which a proper consideration for public safety would not countenance. Frequent reports of disaster from the giving way of particular dams have aroused such wide-spread apprehension regarding all dams as will with difficulty be allayed even by insistence upon State control. Yet the construction of thoroughly safe dams, of which there are many notable examples, is only a matter of adequate expenditure and the proper supervision of designs and construction. In the State, if

anywhere, must be found the authority which will insist on the use of methods and materials which shall provide the required factor of safety.

"The prime inclusive reason for the exercise of State authority over the control of stream flow for power development is that under modern social and economic conditions this step is necessary to ensure the equal participation of all citizens in this form of natural wealth, which is peculiarly the heritage of the whole people. Some of the more particular supplemental reasons for State control have been mentioned in the foregoing. It appears that from all points of view the State is the proper authority to undertake and carry out the conservation of its own water resources. The advantages to be gained by the State in dealing with this natural resource have been forced upon the public mind none too soon. Even though the profits over and above interest, sinking fund and maintenance charges may not appear generous in the near future, our own experience and the experience and observation of our neighbors show that in the not distant future ample returns will result from all reasonable outlay. The next generation will either commend our efforts for prompt action or condemn us for inexcusable delay. Our ancestors found unlimited resources, immense forests which held the deep snows and heavy rainfalls in the strong grasp of their shadows, roots and tangled undergrowth, and permitted them to escape in slow and easy stages all through the dry summer months. The necessity for storage and stream regulation was unknown to them. They did not dream of the possibility of converting their water power into electricity and transmitting it long distances, nor did early industrial and social conditions supply a general market for power at large centers of population. To clear the land was their first effort; to remove the timber and make room for their homes was the ambition of the hardy pioneers. It seemed to them that the streams issuing from the deep, dark forest would run on through the future as they had been running in the past. We of modern times are met with new conditions and must solve new problems. The forests, to a large extent, have been felled or the fires have destroyed them. The flow of our streams

is now more than ever irregular and unreliable, and unless regulated by storage, their value for power purposes is in a large measure lost, while at the same time there is a growing demand for power. The times demand early action, and the State is the authority to which the people must look for relief.

"It does not seem to this Commission that it should be necessary further to urge upon the State the importance of conserving its natural resources. It should be sufficient simply to point the way, so that the Legislature with the prevision of statesmen may adopt the necessary measures. We have no hesitation in saying that the regulation of stream flow and the general conservation of the State's water resources is a State function, and that this State should continue to lead all others in so important a matter by enacting the required legislation, and, if necessary, by amending the fundamental law."

In July, 1911, what is known as the Conservation law was passed. This law created a department of conservation, and concentrated in the hands of three commissioners the duties which had previously been discharged by a number of other boards and commissioners. The salaries of the commissioners were fixed at $10,000 per year. The commission was directed to appoint a chief engineer and a council each at a salary of $7,000, and a number of deputy commissioners, etc. The duties and authority of the commi sion are very broad, and include, among other things, the power to initiate and conduct the construction and development of water power projects, storage reservoirs, works for the improvement of navigation, etc.; to continue investigations of the water resources of the state "so as to complete a comprehensive system for the entire state, for the conservation, development, regulation and use of the waters of the State with reference to the accomplishment of the following public uses and purposes:

(1) The prevention of floods and the protection of the public health and safety.

(2) The supply of pure and wholesome water to municipalities and the inhabitants thereof, and the disposal of sewage.

(3) Drainage and irrigation.

(4) The protection of the public right of navigation."

With respect to hydraulic development, the law reads as follows:

"General powers of commission as to hydraulic development; surplus of canal waters.

"The commission shall have power to make plans, specifications and estimates and to enter into contracts for improvements thereunder and to acquire any necessary lands for the development of hydraulic power of streams with or without stream regulation, subject to such limitations and pursuant to such procedure as may be hereafter provided by law. On certification by the superintendent of public works that at points to be specified by him surplus waters of the canals and canalized streams of the State, including diversion rights held by the State, are available for hydraulic uses, the commission may grant privileges to use the same to municipal or private users. Such grants shall be subject to the needs of navigation and to the jurisdiction of the superintendent of public works over the canals, and the gates through which such surplus waters are drawn shall be located on the canal lands of the State and shall be constructed by the department of public works according to plans prepared by the State engineer and surveyor and operated by the department of public works. No such privilege shall be granted for any term exceeding fifty years from the date of the grant, but any grant may be renewed or a new grant made in the manner herein provided not more than five years prior to the expiration of an outstanding grant, and to take effect on the expiration of the outstanding grant and every such grant shall require payment annually by the grantee to the commission of a rental to be paid into the State treasury for general State purpose sand to be not less than the value of the privileges as appraised by the commission, which appraisal shall be made not more than two years nor less than three months prior to the making of any grant, and the grant shal provided for a readjustment of such rental at the end of every ten ylear period, computed from the date of the grant, at the instance of th e commission or of the grantee, by agreement or by arbitration. No such grant shall be made until after notice given by the commission by publication in two newspapers printed in the county in which the surplus water is located and once a week for four successive weeks, stating the amount of the appraisal and the time and place where bids for the privilege will be ceceived, and no bid shall be accepted which is for a sum less than the value of the privilege as appraised by the commission and except as aforesaid the privilege shall be granted to the highest bidder, but any bid may in the discretion of the commission be rejected for cause, to be stated by it. No transfer of any such privilege shall be made except with the approval of the commission. The commission shall have power to revoke such grants for non-use or when combinations to restrain such use have been enterered into by the grantee, and to provide in such grants or otherwise for securing the payment of the rentals aforesaid and the commission may enforce such payment by suit or other proceedings in the name of the people of this state.

"Codification of laws relating to hydraulic development. The com-

> mission shall prepare and report on or before January fifteenth, nineteen hundred and twelve to the legislature a bill to revise and to consolidate into the conservation law all laws affecting hydraulic development and water storage for power purposes."

Pursuant to this last requirement, the Commission prepared a bill which represents the result of years of study on the part of men specially qualified therefor, and a frank utilization of the best practice and results attained in foreign countries. It is conceded by the commission that in its dealings with the problem of water power development, the Dominion of Canada is at least the peer of any of the nations; and their bill is modeled largely upon the experience of Canada. The bill was introduced into the legislature of 1912. It met with the hearty approval of the Governor, and was passed by the Senate, but failed of adoption by the Assembly. It will be introduced in the next session. In Appendix B details of the bill are given in outline.

RECOMMENDATIONS FOR TENNESSEE

The 57th General Assembly, in passing the resolution calling upon the Tennessee State Geological Survey to "report to the next General Assembly a plan for utilizing and enjoying the water power resources of the State," gave expression to the well-nigh universal demand for some measure of state regulation of the hydro-electric industry. The Survey, through its hydraulic engineer, appeared before the 58th General Assembly, and advocated the passage of a law to this effect. A very suitable bill was introduced into the lower house, but owing to the political conditions existing then, it, like many others, did not receive final consideration.

Very recently the attention of the whole country has been forcibly drawn to the question by the prominence accorded to it in the sessions of the National Conservation Congress, held in Washington in November, 1913.

The recommendations of the Committee on Water Power appointed by that body were adopted by a unanimous vote of the Congress; and they have done much to crystallize public sentiment in favor of regulation, both State and National, of the industry. We quote the following from the committee's report:

> "A grant of the right to use a water power, while differing in some details, is essentially similar to a grant of any other privilege or franchise from the Government, state or national, and its terms, regulations and control should be guided by essentially the same principles necessary to safeguard the rights of the public and of posterity as have been found essential in the case of other classes of franchises from the Government. Particularly is this true in view of the fact that a water power being perpetual will surely tend to increase in value as other sources of power, such as coal and oil, become exhausted. At the same time, for the very purpose of preserving our other power resources which are capable of exhaustion, the development of water power under proper safeguards of the public interest should be earnestly encouraged and hastened. We recommend that

the following principles should govern the granting of a privilege to use a water power.

(a) For a definite period, sufficient to be financially attractive to investors, the privilege should be irrevocable except for cause, reviewable by the courts.

(b) Thereafter the privilege should continue subject to revocation in the absolute discretion of the Government exercised through its administrative board or officer upon giving reasonable notice and upon payment of the value of the physical property and improvements of the grantee as below provided under (h).

(c) After the expiration of the period provided for in (a) above, at recurring intervals of not more than ten years, the amount of compensation to be paid to the Government for the privilege and all the terms and conditions of the grant during the next succeeding period of not more than ten years shall automatically come up for determination by the granting officer of the Government.

(d) The privilege shall be unassignable except with the approval of the Government, in order to safeguard the interests of the Government against speculation in water powers and against appropriation without prompt development.

(e) The privilege shall be granted only on condition of development of the whole capacity of the power site as rapidly as the granting officer may from time to time require, giving due consideration to reasonable market demands and conditions and also on condition of continuous operation, subject to such demands and conditions.

(f) The right to receive compensation for the value of the privilege varying according to the proper conditions of each case shall be reserved to the Government, state or federal, from whom the privilege comes. We believe that the reservation of such a right to compensation is a vital essential towards the end of proper regulation. It is not sufficient to trust that the public will always receive its proper share by means of regulation of rates alone. Local authorities may neglect or may be unable, under conflict of jurisdiction, or for other reasons, to exact in the interest of the public the full value of the public's right. The value

of a water power may in the course of time increase far beyond the power of local regulation to adequately distribute its benefits. At the same time, the method of exacting compensation must be carefully safeguarded so that in case full compensation by rate regulation is exacted by local authorities, an additional burden shall not be imposed. We believe that in normal cases the best method is for the Government to share increasingly in the net profits of the enterprise, provided, these profits exceed a certain reasonable percentage, the right of the Government being recognized otherwise merely by the imposition of a small annual fee or its equivalent.

(g) The Government shall have the right to prescribe uniform methods of accounting for the grantee, and to inspect its books and records.

(h) Upon a revocation of a privilege by the Government, the grantee shall be paid a compensation equivalent to the fair valuation of its property, exclusive of franchise and consequential damages; this compensation shall include such appurtenances as are necessary for the operation of the water power and the transmission of electricity therefrom, but shall not include such properties as railroads, lighting systems, factories, etc., which are of themselves separate industries.

In such transfer all contracts for the sale or delivery of power made in good faith previous to such notice of transfer should be assumed by the transferee, so that the said grantee may operate and maintain the power business during his occupancy of the property under such stable guarantees as may beget confidence therein by prospective long term contractors, provided that the Government or said transferee shall not assume any contracts made at a price or under conditions which shall be determined by the proper administrative officer of the Government to be unreasonable or confiscatory."

These recommendations are by no means radical and the Survey believes that they should be made the basis of a law to be enacted by the next General Assembly. With such a law upon the Statute books, the interests of the people would be amply safe-guarded;

and then if public sentiment grows toward a belief in the more advanced policy, now advocated by the Conservation Commission of New York, of the welding of all the water power developments within the state into one single extensive system of power development and power distribution which shall embrace the entire state, and benefit every community within its borders, such a policy could be made effective by later successive enactments.

The advocacy of any policy too far in advance of a general public recognition of the wisdom of or the necessity for such a policy does little practical good. However some excellent purpose may be served if we point out at this time the inherent potentialities that lie unutilized, and as yet generally unrecognized in this field.

It may be asserted then that although the water powers of Tennessee are located for the most part in the eastern division of the State, there is no reason either of an economic or an engineering nature why these powers might not be developed by the State, and by means of a comprehensive system of power transmission be made to benefit every community within our borders. Not only might the State sell power at a slight advance above the actual cost of production and transmission to all its municipalities to be sold in turn by them to all citizens without discrimination at a rate only sufficiently above cost to amortize the investment; but it would also lie within the power of the State to use its water power resources to benefit enormously the farming interests not of the eastern division alone, but of the entire State. There is no reason why the water powers of the Great Smoky Mountains should not operate centrifugal pumps to drain the swamps of western Tennessee. The use of electricity on the farms of Tennessee might be, and should be, almost universal. Were it so, no argument is needed to prove that the agricultural interests of the State would be advanced by leaps and bounds. Uses for power on the farms, now beyond the dreams of the ordinary farmer, are urgently pressing for realization; and it is no exaggeration to say that it is within the reach of the State,by means of its water powers, to double or treble the value of its agricultural resources.

Lest the writer be accused of indulging in impractical fancies, attention may be called to the experiences along this line in in some of our sister states.

Quoting from a paper on "Electricity on the Farm" recently read by Mr. Putnam A. Bates, E. E., before the American Institute of Electrical Engineers, we have the following:

"Never in the history of this country has there been such a great arousing of public opinion, such an arousing of interest of the people generally, in the agriculture of the country. We are commencing to appreciate that while in the early years of the past century, two-thirds of our people were engaged in the producing business, producing food and clothing for the people, now but one-third are so engaged. And it also seems to be pretty clearly demonstrated that the average earning of the average farmer has netted too small a return for his labor. In many parts of the country, what he did earn was earned at too great a personal sacrifice—labor for long hours and no recreation. Plainly speaking, we have wakened up to the situation that though the yearly crop figures seem to indicate an abundance, we are actually approaching the condition where demand will soon exceed supply, and in most instances, the farming business is badly out of gear and needs reorganizing. It has fallen to the lot of the electrical engineer to take a hand in many matters of reorganization, and I believe agriculture now requires his attention.

"Betterment of the farmers' conditions and improved efficiency in all the operations involved in his work is the cry of the day. Bankers and business men's associations, federal departments, agricultural colleges and important engineering organizations are giving this feature of the country's welfare careful study, and yet there is perhaps no one improvement that may be counted upon to so radically benefit the farmer as the introduction of electricity on the farm.

"The electric farm, however, is not a new idea, for several farms well worthy of this name have been in successful operation for some ten or twelve years. and perhaps longer than this. But there has been very little organized effort in disseminating existing knowledge on the practical use of electricity in agriculture, with the result that farms so equipped are generally regarded with suspicion and possibly in the light of a hobby.

"I shall endeavor to show that such a point of view may at once be dismissed and we may look for a general use of electricity on the better class of farms in this country before

many more years have elapsed. As a matter of fact, electricity is now being utilized for ligh ing and power purposes on a much larger number of American farms than perhaps many of us have heretofore realized.

"Let us consider for a moment the farms of our great Southwest. In some sections of that wonderfully fertile country, well protected by the high mountain ranges, practically every farm is an electric farm. That is to say, the buildings are lighted by electricity and many of the laborious operations are accomplished by the use of electric power. These really were our first electric farms, the period of their establishment corresponding with the development of the water powers of the nearby mountains.

"On the majority of these farms, irrigation is practiced and quite naturally electricity was first made use of for pumping purposes. Then under the influence of progressive local central station operators, it was almost universally adopted for light.

"I can recall seeing electric lights and the electric flat iron in use in the farm homes on the Pacific Coast, eleven years ago. The people were content to enjoy the advantages which these improvements made possible to them, but did not seem to regard their conditions as unusual. Their farms were in fact electric farms and their industries dependent upon the produce of the land were, as they are now, practically all operated by electricity. I refer to the canneries, fruit packing houses, etc.

"* * * In some instances practically the entire supply of the central station current was at once engaged for lighting, heating and power uses on the farms. This was the case ten years ago in the instances I speak of, and according to reports I have just received, the situation has not materially changed, except that both supply of and demand for the current have increased.

"Such electric service plants may be regarded as farmers' central stations and I shall commence my illustrations with a description of the Mount Whitney Power and Electric Company's service in the vicinity of Visalia, Cal. This will serve as an illustration of a plant of this class.

"Some of the farms in this district are large farms of

several hundred acres, but the majority are small truck and fruit farms, ranging from 10 to 40 acres, an average of about 20 acres to each person, the total number of acres irrigated by electric power from the Mt. Whitney plant approximating 25,000, and representing about 6,000 horse power in electric motors.

"In the Exeter district, where an 800-acre farm is located there are 32 plunger pumps aggregating 96 h. p. and 16 centrifugal pumps aggregating 125½ h. p. And in the Lindsay district, comprising about 25 square miles, there are in operation 217 pumping plants with a total connected horse power of 1794, of which 113 were plunger pumps (1100 h. p.) and 104 centrifugal pumps (694 h. p.). The total pumping load connected to the company's system is 374 plunger pumps, (2385 h.p.) and 256 centrifugal pumps, (2471 h. p.) or a total of 630 pumping plants with 4856 h. p., being on the average, 7.7 h. p. for each pumping plant.

"The farms served by the Mt. Whitney system may be termed electrically irrigated farms, as in all cases the farmer operated his irrigation pumps by electricity. The details of this class of business it will be seen are well established. Electric companies in other sections have also built up business of this kind and in doing so have followed the same lines or a modification of them.

"Another hydro-electric development and distribution system where irrigation pumping forms an important portion of the total load is that of the Pacific Power & Light Company.

"The lines of this company traverse a fertile farming district lying in the southeastern corner of the state of Washington, just east of the Cascade Mountains. Several power developments are connected together making a complete distribution system, serving a total population of 101,900, including 39 towns, having an average population of 2,500. In addition to the towns, the population of the rural communities is 5,000.

"There are 300 miles of primary lines at 66,000 volts, with 500 miles of 6600 volt secondary.

"All of the plants making up this company's system are illustrations of a generating station designed to meet the

lighting and power demands of a growing farming community.

"The San Joaquin Light and Power Corporation of Fresno, California, supplies electric service to seven counties in one of the most fertile farming sections of the country. The actual area being more than 200 miles long and 75 or 80 miles wide.

"Pump irrigation results in intensive farming. And this is the direction in which our agriculture is moving. It may also be added that the power required for pumping has proven to be the opening wedge in introducing the use of electricity in the majority of those farming districts where dependence upon this form of energy has become established. The most scientific farming can be done only by pump irrigation where the work can be arranged and the farm run just as systematically as some of the big manufacturing and commercial undertakings.

"Regarding irrigation in humid districts, Mr. Milo B. Williams, Irrigation Engineer of the U. S. Department of Agriculture, states that it is the distribution of rainfall with respect to need of different crops which determines the necessity for irrigation in a locality. Drought records for several years past have led the National Department of Agriculture to encourage supplemental irrigation in the humid regions as a vital factor in crop insurance.

"The most humid portion of the agricultural east is subject to the greatest irregularity of rainfall. This refers to the southern states bordering on the Gulf of Mexico and the Atlantic Ocean. Here the normal annual precipitation ranges from 45 to 55 inches and yet these states are subject to droughts lasting from 20 to 60 days or more during the growing season. Irrigation in various parts of Alabama, Georgia and Florida, has resulted in producing very profitable crops on land which has heretofore failed to yield sufficient returns to pay for cultivation. Irrigation will do for the South what it has done for the West. It will insure results to the small farmer. The coming of the small farmer to the South will cause the passing away of ruined plantations, as his going to the West has caused the passing away of great deserts and wasteful wheat ranches.

"The South today represents one of the largest areas of dormant latent agricultural possibilities in this nation and when drainage of the low lands is coupled with the general practice of irrigation throughout our South and our East, much in the same way that water distribution has been conquered in our West, we will have added many millions of acres to the productive area of this great country.

"These are great problems and promise an immense work for years to come, but the beneficial results will outweigh many times the cost and labor that will be necessary to bring them about. At present, an abnormal condition exists just as it did in the arid sections before irrigation was practiced, and it is the writer's opinion that the reclamation of the worn out farms and the barren lands of the Southern States presents agricultural opportunities unsurpassed at this time by any section.

"In the drainage of water-soaked lands, as in irrigation, electric power may be used for short lift pumping. And as an indication of the magnitude of the work ahead of us in this field alone, it is sufficient to quote from the statistical records of the United States of 1910, issued by the Department of Commerce and Labor, which place the total swamp area and overflowed lands at a total of approximately 75,000,000 acres."

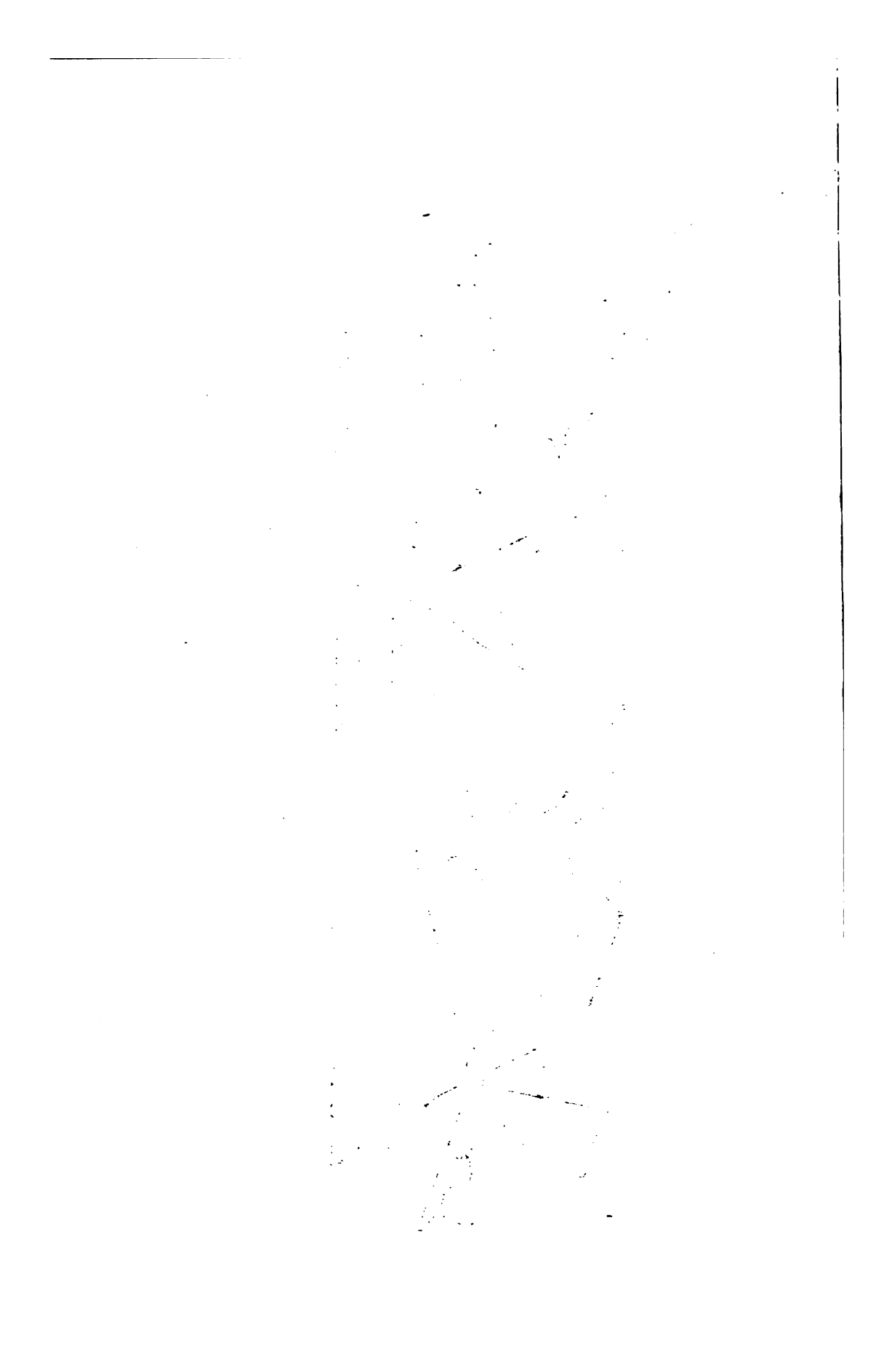
What an inspiring vista this opens to the imagination here in Tennessee! In comparison with our dormant potentialities how small a fraction have we yet brought to realization! If we have the will to make it so, our latent water powers may become the key to unlock a measure of wealth beyond the dream of the average man. Who can picture the beneficence of a million horse power? But the heritage of Tennessee is more than two million horse power to come from her tumbling waters when she concludes to utilize them.

We include in this bulletin a map of Tennessee, with a possible trunk line transmission system indicated thereon. It must be understood, of course, that no actual location could be made without a considerable amount of field study, and the map is intended only as a suggestion of a possibility not yet generally recognized.

The policy here suggested would be new to Tennessee. This is granted. If the objection were raised that such a policy would

PLATE I.

MAP OF TENNESSEE, SHOWING A POSSIBLE SYSTEM OF POWER TRANSMISSION FOR THE ENTIRE STATE



be paternalistic and hence dangerous, the reply is that it does not suggest action beyond the limit of the legitimate functions of the state. The citizenship of the state differs from that of a municipality only in point of size. If it be legitimate for a city to supply its citizens with water, with light and with power, how may it be argued that for a state to do so is essentially different? Is it illegitimate for the state to save its citizens needless expense? So to use its natural resources as to distribute their value among all the citizenship?

A Tennessee Conservation Commission could be placed in position to do for the municipalities of Tennessee what the Canadian Hydro-electric Power Commission has done, for example, for the city of Ottawa. Prior to 1906 that city was supplied with electricity by a private corporation. The rates then in force were:

15 cents net per kilowatt-hour for light;
$40.00 and up per horse power for power;
$65.00 per arc lamp for lighting the streets.

At that time the Commission began furnishing electricity to the city and the rates were reduced to:

7 1-5 cents net per kilowatt-hour for light;
$25.00 per horse power for power;
$45.00 per arc lamp for street lighting.

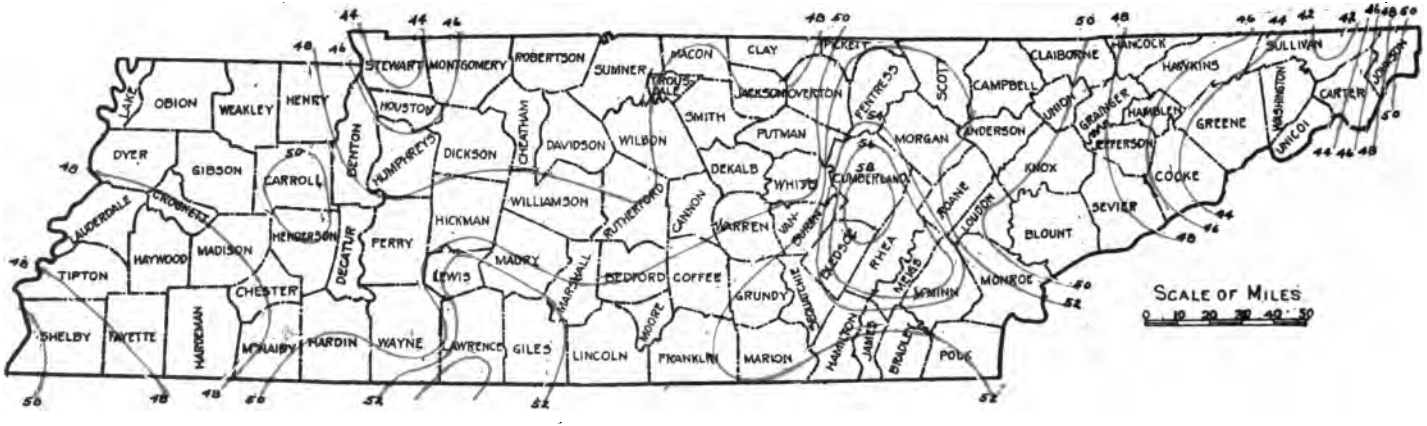
In 1911 the rate for lighting was further reduced to 5.4 cents per kilowatt-hour. In three years the number of users of electricity increased from 1200 to 3,000; and the power consumption from 800 horse power to 2,300. The city pays the Commission only $15.00 per horse power for the power, and the difference between this price and the selling prices given above, returns to the city a net profit of above $10,000.00 a year. The total saving either to the city or to its citizens is in excess of $150,000 00 a year. 98 per cent of the population of Ottawa are now using electric light.

As will be shown later, the latent water power resources of Tennessee are in excess of one million horse power. By the inauguration of a broad policy of water storage which, with the cooperative assistance of the neighboring states of Kentucky, Virginia, North Carolina and Georgia, could be put into effect so as to cover the entire drainage basin of the Tennessee and the Cumberland Rivers, the fair division of the benefits to accrue would allot to Tennessee a much larger total horse power; probably between 2,000,000 and 3,000,000. But taking the figure, 1,000,000, it

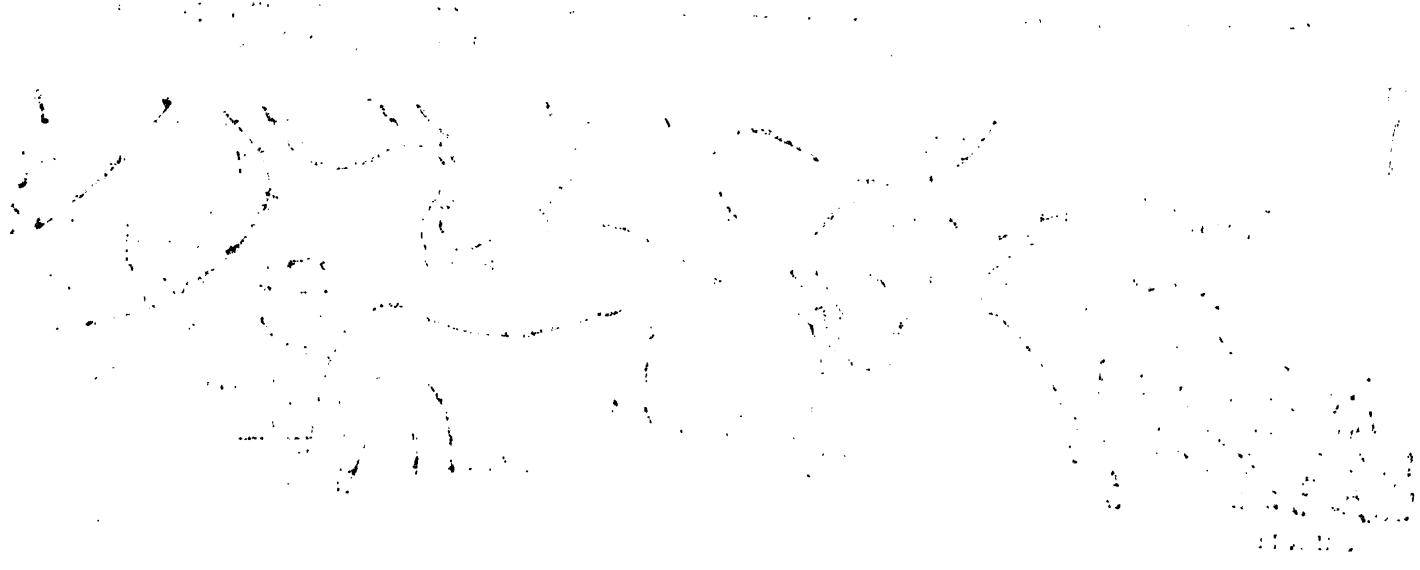
may be safely stated that the yearly rental value of this power would be not less than $10,000,000. Alloting $3,000,000 as an ample allowance for interest on cost of construction, maintenance, and operation, a net balance of $7,000,000 as an annual income to the State is the pleasing possibility presented.

> "The State and its citizens would be in this way directly benefited. The indirect benefits to the State will be much greater. Counting the families of those to whom employment will be afforded and the storekeepers, farmers, mechanics, and business and professional men indirectly supported, it may be safely said that at least one person is supported by every horse power developed. The same point is illustrated in another way by the towns that spring up and flourish at every water power site. Thus the 1,000,000 of horsepower added to our water powers will mean a living for 1,000,000 more people. It is, therefore, evident that the property necessary to house these people, the mills, factories and railways, etc., in which the power will be used, all mean a wealth from which the usual contribution in taxes will indirectly furnish an enormous income to the State. To be definite, these 1,000,000 people will pay in State, city, town, county, school and special taxes at usual rates, $16,000,000 yearly. Here is the question then: Shall the State remain passive and ultimately allow this priceless possession of water power to remain unused or shall it in the march of civilization keep step with new demands and new conditions? The passage of a law that permits the use of a natural resource for new purposes is well within the general definition of public use as established in various decisions of the courts. Building a storage reservoir will stimulate industrial energy and promote the productive power of a very large population in the portion of the State affected, besides leading to the growth of towns and the creation of new channels for the employment of capital and labor in those other centers, as well as in places to which electrical energy can be carried. So all over the State industrial opportunities are waiting for a strong and skillful hand to apply the electric spark that will set in motion many hands and wheels. A general policy for the systematic development of the State's water resources would quickly become an important factor in the general welfare of all our people and, therefore, has a real "public purpose." Such a general policy is in harmony with the true spirit of democratic government."

PLATE II



RAINFALL MAP OF TENNESSEE, SHOWING THE MEAN ANNUAL RAINFALL IN INCHES.
(Compiled and drawn by J. F. Voorhees, local Forecaster, U. S. Weather Bureau, Knoxville, Tennessee.)



THE AVAILABLE WATER POWER IN TENNESSEE

Introduction.—The investigations of the U. S. Geological Survey give a basis for estimating with a fair degree of precision the available water power in the State. Yet to place a definite figure on the horse power which may be developed even at a single water power site is not easy. The flow of a stream fluctuates from season to season over a very wide range, and even from hour to hour there is frequently a measurable variation. The amount of power which may be taken from a stream by building a dam of a given height is therefore subject to very great variations. If the dam be built at a point such that it will create a pool of moderate dimensions, then the waters of the night flow may be stored in part for use the succeeding day, and by this device nearly double the amount of power may be made economically available that would otherwise be possible. Again, if the dam creates a pool of very large dimensions, the flood waters of the wet season may be stored and carried over to augment the low flow of the dry season. These and other considerations of an engineering character require that special study be devoted to each and every water power project before even its magnitude may be certainly known. It is considered good engineering practice at the present time to build a water power plant of such capacity that for 60 per cent of the year the river will furnish water enough to develop the full power of the plant, and to depend upon auxiliary steam power to supply the deficit when water is lacking.

Reservoir System.—The full development of the water power resources of the State cannot be realized until a complete system of storage reservoirs is designed and built so that all the flood waters of all the principal streams may be impounded, to be released at such times and in such volumes as to result in a practically uniform flow of water throughout the year. Colossal as such an undertaking undoubtedly will be, it is an impossibility neither from an engineering nor an economic standpoint. A work of this nature cannot be undertaken by individual initiative; only the sov-

ereign power of the State is sufficient to cope with such a task. Were the State to begin this work tomorrow, decades would pass before the complete scheme of conservation could be realized. Whether it be generally recognized or not, whether a beginning be made in the present decade or not for years to come, it is the destiny of the State to accomplish this task.

It is not believed that the full realization of this scheme, even if it could be carried out at once, would immediately be economically justified. But a beginning could not be made too soon. The economic value of the water power, of the lessening of flood damage, of the improvement of navigation, would justify the expenditure of many millions of dollars at as early a date as the necessary preliminary studies could permit of a beginning being made.

Cooperation of Other States Needed.—The river system of Tennessee is not bounded by the political boundaries of the State. No complete system of water conservation could be worked out wholly within the State. For this reason the State should seek to effect some form of coöperative arrangement with the States of North Carolina, Georgia, Virginia and Kentucky, whereby an equitable division could be made both of the expense of such an undertaking and of the benefits to be derived therefrom.

For example, could the States of Tennessee and Virginia secure complete control of the beds and the watersheds of the Clinch and Powell Rivers by concerted and coöperative action, a complete system of water conservation covering these particular streams would immediately be a feasible undertaking; and the benefits which the two States would derive, now and for all future time, would be enormously greater than could possibly flow from the development of power on the streams by any private corporation.

Reservoirs Tentatively Located.—The U. S. Geological Survey has very courteously given us access to the original data which has been accumulated in its study of the relation of the Appalachian Mountains to the development of water power and to the development of inland navigation, some of which have not yet been published. In the course of this study, a number of storage reservoirs have been tentatively located, some of them more with a view to improving navigation than to developing water power. A more intensive study of the problem than the U. S. Geological Survey has had either the time or the means to make, whether pursued by that body or by the Tennessee Geological Survey or by a conservation commission, would undoubtedly result in mak-

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ing a number of changes both in the location and the extent of these reservoirs. This fact does not detract from the value of the work already done, nor does its statement imply any criticism of the work.

Reservoir Sites in the Tennessee River Basin.—No study of this nature has yet been made of the Cumberland River basin; but table 1 contains the data for twenty selected reservoir sites in the Tennessee River basin. The exact location and the extent of these proposed reservoirs is shown in green color upon the water power map of Tennessee which has been prepared for this bulletin.

TABLE 1. *Selected reservoir sites in the Tennessee River Basin.*

Stream and Location	Catchment area.	Mean annual run-off per square mile.	Flow available.	Capacity of reservoir.	Capacity of reservoir in catchment area.	Height of dam.	Area of flow line.
	Sq. miles	Cu. feet per sec.	Cu. ft. per sec.	1,000,000 cu. ft.	Sq. mi.	Feet	Acres
Clinch River Scott County, Va.	780	1.38	1,080	30,400	690	180	10,000
Nolichucky River, Greeneville, Tenn.	940	1.69	1,590	14,700	270	100	10,200
Clinch River Sneedville, Tenn.	560	1.38	770	18,500	390	100	8,500
Powell River Jonesville Va.	570	1.38	790	17,100	380	100	12,000
Holston River North East of Knoxville, Tenn.	3,400	1.56	5,300	163,500	3,300	160	49,000
French Broad River East of Knoxville, Tenn.	4,050	1.56	6,300	199,600	4,000	200	70,000
Little River South of Knoxville, Tenn.	290	1.56	450	17,400	290	94	12,100
Little Tennessee River Loudon County, Tenn.	2,520	2.78	7,000	78,000	860	100	54,400
Little Tennessee River Swain County, Tenn.	380	2.78	1,050	7,340	80	100	5,120
Clinch River Roane County, Tenn.	2,110	1.38	2,900	26,500	600	60	30,000
Cheoah River Graham County, N. C.	180	2.78	500	6,700	75	150	2,840
Hiawassee River Cherokee County, N. C.	550	2.63	1,450	32,400	380	200	11,080
Nottely River Union County, Ga.	240	1.70	410	1,000	20	40	1,680
Toccoa River Fannin County, Ga.	240	2.14	510	4,130	60	100	2,880
Hiawassee River Hiawassee, Ga.	100	2.63	260	2,240	40	100	1,600
Little Tennessee River, Rabun County, Ga.	50	4.35	220	2,720	20	50	3,800
Hiawassee River Near mouth, Tennessee	2,040	2.12	4,300	77,500	1,130	70	70,000
West Chicamauga Creek Walker County, Ga.	80	2.00	160	5,260	80	60	6,300
South Chickamauga Creek Catoosa County, Ga.	110	2.00	220	6,330	100	60	7,400
Sequatchie River Sequatchie County, Tenn.	330	2.00	660	4,000	60	50	5,500

Below Riverton the slope of the Tennessee River is too gradual to admit of any water power developments. Above Riverton the river has a total drainage area of 30,800 square miles, and a minimum discharge of 12,000 cubic feet per second. The storage represented by the twenty reservoir sites in the table above would be sufficient to conserve the flood discharge from 12,800 square miles, or about forty per cent. of the total in the drainage basin. The storage facilities in the basin are enormous, the above table representing but a part of the possible storage.

Neither in the above table nor in those to follow is regard given to political boundaries. In reproducing the data we have added to each table a column naming the State or States in which the power development listed in located. We shall follow these tables then with one summarizing the power developments possible without storage and with storage wholly within the State of Tennessee.

The following tables on the water power of rivers in East Tennessee, are taken from Circular 144, U. S. Department of Agriculture, Forest Service, by Leighton, Hall and Bolster:

Tennessee River

Considering the main stream from Riverton to the mouth of Holston River, there are two sections along which a great horse power is indicated. The first section from Riverton to the head of Elk Shoals is 60 miles long and has a total fall of 165 feet. The minimum indicated horse power thereby produced is 162,000, and the minimum for the 6 highest months would be 275,000. The increase from storage, considering full reservoirs, would be as follows:

Distributed over 1 year	Horse Power	396,000
Distributed over 6 months		792,000
Distributed over 3 months		1,584,000

The next section extends from The Pan to Chattanooga, a distance of 20 miles, with a total fall of 28 feet. The minimum discharge along this section is 10,000 cubic feet per second, giving a minimum indicated horse power of 22,900, or a minimum for the 6 highest months of 38,900. This would be increased by storage, considering full reservoirs, as follows:

Distributed over 1 year	Horse Power	67.000
Distributed over 6 months		134,000
Distributed over 3 months		268,000

A short distance above Knoxville, Tenn., the Holston and French Broad rivers join to form the Tennessee.

HIWASSEE RIVER.

From the mouth of the Hiwassee to Ocoee River, a distance of 35 miles, the fall is only 33 feet; therefore, this stretch is not available for the practical development of power. The indicated horsepower for the remainder of the stream is set forth in Table 2.

TABLE 2.—*Indicated horse power developed by Hiwassee River.*

Section of river.	State	Length	Mean Drainage area.	Minimum Discharge.	Minimum Discharge during six high-water months	90% of total fall.	Minimum horse power.	Minimum horse power during 6 high-water months.	Horse power available from storage during a period of—		
									12 months.	6 months.	3 months.
Hiwassee River:											
From Ocoee River to Savannah Ferry	Tenn.	Mi. 9	Sq.Mi. 1,310	Sec.ft. 972	Sec.ft. 1,560	Feet. 20	1,750	2,790		Submerged.	
From Savannah Ferry to Reliance	Tenn.	6	1,220	915	1,460	36	3,000	4,800	3,500	7,000	14,000
From Reliance to Coco Creek	Tenn.	9	1,150	874	1,400	153	12,200	19,400	17,000	34,000	68,000
From Coco Creek to Turtletown Creek	Tenn.	3									
From Turtletown Creek to Apalachia	Tenn.	3	1,060	806	1,290	*231	15,200	24,300	23,100	46,200	92,400
From Apalachia, Tenn., to Apalachia, N. C.	T.-N. C	2									
From Apalachia, N. C., to Beaverdam Creek	N. C.	14	1,000	780	1,250	131	9,270	14,800		Submerged.	
From Beaverdam Creek to Nottely River	N. C.	15	910	710	1,140	136	8,780	14,000		Submerged.	
From Nottely river to Valley Riv.	N. C.	5	560	437	699	46	1,830	2,920		Submerged.	
From Valley River to Brasstown Creek	N. C.	7	390	320	512	63	1,840	2,930	445	890	1,780
From Brasstown Creek to Shooting Creek	N. C.	18	240	240	384	205	4,470	7,160	1,450	2,900	5,800
From Shooting to Hightower Creek	N.C.-Ga.	10	110	121	194	117	1,290	2,060	670	1,340	2,680
Total							59,630	95,160	46,165	92,330	184,660

*Mean head.

Tributaries of Hiwassee River.—The principal tributary of the Hiwassee is the Ocoee, which has a total drainage area of 635 square miles. Along the upper 57 miles of its course the name Toccoa is given to the river. The indicated horse power along the entire section is set forth in Table 3.

TABLE 3.—*Indicated horse power developed by Ocoee-Taccoa River.*

Section of river.	State	Length	Mean Drainage Area.	Minimum Discharge.	Minimum Discharge during six high-water months	90% of total fall.	Minimum horse power.	Minimum horse power during six high-water months	Horse power available from storage during a period of—		
									12 months.	6 months.	3 months.
Ocoee River:											
From mouth to Sylco Creek	Tenn.	Mi. 16	Sq.mi. 600	Sec.ft. 600	Sec.ft. 960	Feet. 70	3,830	6,140	567	1,134	2,268
From Sylco Creek to Big Creek	Tenn.	3	550	578	925	57	2,980	4,770	745	1,490	2,980
From Big Creek to Bush Creek	Tenn.	13	500	550	880	522	26,100	41,800	6,850	13,700	27,400
From Bush Creek to Fightingtown Creek	Tenn.	5	440	506	810	34	1,580	2,520	Limited amount.		
Toccoa River:											
From above Fightingtown Creek to Blue Ridge Station, Morganton Bridge	Ga.	15	300	390	624	92	3,260	5,210	1,210	2,420	4,840
From Blue Ridge to Dial Station	Ga.	21	180	252	403	280	6,440	10,300	Fall reduced one-third by Toccoa reservoir.		
From Dial Station to Coopers Creek	Ga.	7	100	145	232	153	2,020	3,220	None.	None.	None.
Total							46,210	73,960	9 372	18,744	37 488

EXPLANATORY NOTE.—Mouth of Ocoee to Sylco Creek—fall reduced 30 feet by proposed Hiwassee reservoir

The remaining tributaries of Hiwassee River afford good power sites for limited development, but the drainage areas are, in the main, so small that they will not be considered in this report except in the case of Nottely River, which enters the Hiwassee near Murphy, Tenn. The Nottely develops an indicated horse-power as follows: From the mouth to Ranger, a distance of 9 miles, there is a total fall of 85 feet and a minimum discharge of 224 cubic feet per second, which will provide for a minimum indicated horse power of 1,560. The minimum for the 6 highest months is 2,490. From Ranger to Young Cane Creek, a distance of 20 miles, of which 5 miles is in Tennessee, there is a fall of 155 feet and a minimum flow of 187 cubic feet per second, which will provide for a minimum indicated horse power of 2,380. The minimum for the 6 highest months is 3,800. This power would be obliterated by the Nottely reservoir.

CLINCH RIVER.

The tributary of the Tennessee river of next importance is

Clinch River, which has a drainage area of 4,390 square miles. The indicated horse-power along this stream is set forth in Table 4.

TABLE 4.—*Indicated horse power developed by Clinch River.*

Section of river.	State.	Length	Mean Drainage Area.	Minimum Discharge.	Minimum discharge during six high-water months	90% of total fall.	Minimum horse power.	Minimum horse power during six high-water months	Horse power available from storage during a period of—		
									12 months.	6 months.	3 months.
Clinch River:		Mi.	Sq. mi.	Sec.	Sec. ft	Feet					
Fr. Emory Creek to Clinton	Tenn.	55	3,200	960	1,440	68	5,895	8,840	Submerged		
From Clinton to Powell River	Tenn.	31	2,840	852	1,280	50	3,834	5,740	10,300	20,600	41,200
From Powell River to near Sycamore Creek, Southern Railway bridge	Tenn.	48	1,740	522	783	133	6,318	9,456	20,600	41,200	82,400
From near Sycamore Creek, Southern Railway bridge, to N. Clinch River	Tenn.	45	1,450	435	652	171	6,750	10,100	19,500	39,000	78,000
From North Clinch River to Clinchport station	T.-Va.	20	1,070	321	482	54	1,575	2,360	Submerged.		
From Clinchport station to Indian Creek	Va.	110	550	165	248	680	10,125	15,210	8,600	17,200	34,400
"							34,497	51,700	59,000	118,000	236,000

EXPLANATORY NOTES.—Fall between Southern Railway bridge and North Clinch River reduced to 140 feet by Sneedville reservoir. Fall between Clinchport and Indian Creek reduced to 100 feet by Clinch River reservoir.

Tributaries of Clinch River.—The most important tributary is Powell River, which has a total drainage area of 940 square miles. The amount of indicated horse-power along various sections of this river and designated tributaries is set forth in Table 5.

LITTLE TENNESSEE RIVER.

Above the Hiwassee and Clinch, on the Tennessee River, is the Little Tennessee, a stream having a total drainage area of 2,650 square miles. The indicated horse power developed along various sections of this stream is set forth in Table 6.

TRIBUTARIES OF LITTLE TENNESSEE RIVER

Some of the tributaries of Little Tennessee River are quite as important, from the standpoint of power development, as the main stream itself.

TABLE 5.—*Indicated horse power developed by Powell River and Tributaries.*

Section of river	State	Length.	Mean drainage area.	Minimum discharge.	Minimum discharge during 6 high-water months.	90 per cent total fall.	Minimum horse power.	Minimum horse power during 6 high-water months.	Horse power available from storage during a period of—		
									12 months.	6 months.	3 months.
Powell River:		Mi.	Sq. mi.	Sec.ft.	Sec. ft.	Feet.					
From mouth to North Powell	T.-Va.	100	610	183	274	387	6,440	9,630	9,640	19,280	38,560
From North Powell to South Powell	Va.	17	170	51	76	198	918	1 380	None.	None.	None.
From South Powell to Callihan Creek	Va.	4	101	30	45	54	144	216	None.	None.	None.
North Fork, Powell river, from mouth to head	Va.	17	*91	27	40	†330	810	1,220	None.	None.	None.
South Fork, Powell river, from mouth to head	Va.	12	*37	11	16	†730	730	1,100	None.	None.	None.
Copper Creek, from mouth to head	Va.	41	*136	41	62	†336	1,250	1,880	None.	None.	None.
Guest River, from mouth to head	Va.	19	*96	29	44	†480	1,270	1,900	None.	None.	None.
Maiden Spring Creek, from mouth to head	Va.	35	*119	36	54	†430	1,400	2,100	None.	None.	None.
							12,962	19,426	9,640	19,280	38,560

*Total area. †Mean head.

EXPLANATORY NOTE.—Water fall between mouth and North Powell reduced to 200 feet by Jonesville reservoir.

Tellico River, in Tennessee, is a stream having a total drainage area of 284 square miles. From the mouth to Tellico Plains, a distance of 22 miles, there is a fall of 120 feet, which, with a minimum discharge of 125 cubic feet per second, will furnish a minimum indicated horse power of 1,224. The minimum for the 6 highest months will be 1,960. This part of the river would be submerged by the proposed Loudon reservoir. From Tellico Plains to the head of the river is a distance of 18 miles, with a total fall of 1,600 feet. Considering 700 feet of this as a mean working head, with a discharge of 102 cubic feet per second, the total minimum indicated horse power is 6,490, and the minimum for the 6 highest months will be 10,400.

Citico Creek, in Tennessee, a tributary 17 miles long, has a total mean head of 470 feet. The minimum discharge is 58 cubic feet per second, which will provide for a minimum indicated horse power of 2,480. The available fall would be reduced 40 per cent by the proposed Loudon reservoir.

TABLE 6.—*Indicated horse power developed by Little Tennessee River.*

Section of river.	State	Length.	Mean drainage area.	Minimum discharge.	Minimum discharge during 6 high-water months.	90 per cent total fall.	Minimum horse power.	Minimum horse power during 6 high-water months.	Horse power available from storage during a period of—		
									12 months.	6 months.	3 months.
Little Tennessee River:											
From mouth to below Tellico River, McGhee Station	Tenn.	Mi. 20	Sq.Mi. 2,560	Sec.ft. 2,050	Sec.ft. 3,280	Feet. 27	5,030	8,050	6.370	12,740	25,480
From above Tellico, McGhee, to Abraam's Creek	Tenn.	19	2,100	1,780	2,850	63	10,200	16,300	Submerged.		
From Abrams Creek to Tuckasegee River	T.-N.C.	38	1,670	1,500	2,400	567	77,300	123,000	21,000	42,000	84,000
From Tuckaseegee River to Nantahala River	N. C.	7	657	650	1,040	90	5,320	8,510	2,820	5,640	11,280
From Nantahala River to below Cullasaja River, Franklin	N. C.	28	380	418	669	387	14,700	23,500	7,050	14,100	28,200
Total							112,550	179,360	37,240	74,480	148,960

EXPLANATORY NOTES.—Fall between mouth and McGhee reduced to 24 feet by Loudon reservoir. Fal between Nantahala and Cullasaja reduced to 250 feet by Swain reservoir.

Abrams Creek, in Tennessee, 15 miles long with a drainage area of 94 square miles, has a total fall of 1,110 feet. Considering 580 feet of this as a reasonable mean head, with a minimum discharge of 75 cubic feet per second, there will be developed a total minimum indicated horse power of 3,950. The minimum for the 6 highest months will be 6,320 horse power.

Cheoah Creek, in North Carolina.—This is another important tributary of Little Tennessee River, with a total drainage area of 212 square miles. From the mouth to Snow Bird Creek, a distance of 13 miles, there is a total fall of 800 feet, with a minimum run-off of 130 cubic feet per second, which will produce a minimum indicated horse-power of 8,500. The minimum for the 6 highest months will be 13,600. On the same river from Snow Bird Creek to Tallula Creek, a distance of 4 miles, there is a total fall of 110 feet, which will produce a minimum horse power of 396 with a discharge of 44 cubic feet per second. This power would be reduced approximately 50 per cent by the Cheoah reservoir. There are several tributaries of Cheoah Creek, such as Santeetla,

Snow Bird and Tallula creeks, which furnish fairly good sites for limited installation.

Tuckaseegee River.—The most important tributary of Little Tennessee River is the Tuckaseegee, in North Carolina, which has a drainage area of 752 square miles. The indicated horse power along certain sections of this river is shown in Table 7.

TABLE 7.—*Indicated horse power developed by Tuckaseegee River.*

Section or river.	State	Length.	Mean drainage area.	Minimum discharge.	Minimum discharge during 6 high-water months.	90 per cent total fall.	Minimum horse power.	Minimum horse power during 6 high-water months.	Horse power available from storage during a period of—		
									12 months.	6 months.	3 months.
Tuckaseegee River											
From Bryson City to Oconalufty River	N. C.	Mi. 6	Sq.Mi. 635	Sec.ft. 540	Sec.ft. 864	Feet 63	3,100	4,950			
From Oconalufty River to Scott Creek	N. C.	16	375	319	510	144	4,180	6,680			
From Scott Creek to East Laport Station	N. C.	10	245	208	332	108	2,040	3,270			
From East Laport Station to West Fork	N. C.	6	174	157	251	63	900	1,440			
Total							10,220	16,340			

The Tuckaseegee itself has important tributaries, the most noticeable of which is the Oconalufty, which has a drainage area of 201 square miles. In the lower 5 miles of this stream there is an approximate fall of 150 feet, with a minimum discharge of 156 cubic feet per second, which will produce a minimum indicated horse power of 1,920. The minimum for the 6 highest months will be 3,060 horse power.

Nantahala River, in North Carolina.—This river is 43 miles long and has a total drainage area of 180 square miles. Along the first 12 miles there is a total fall of 500 feet and a minimum run-off of 176 cubic feet per second, indicating a minimum horse power of 7,200. The minimum for the 6 highest months would be 11,500. In the next 18 miles of the river there is a fall of 1,100 feet, about 80 per cent of which could be utilized. The minimum flow is 120 cublic feet per second, which would produce a minimum indicated horse power of 10,800, and the minimum for the 6 highest months would be 17,300 horse power. There are many other

tributaries of the Little Tennessee providing good power sites for limited installation, but they will not be discussed in this paper.

FRENCH BROAD RIVER.

The main stem of the Tennessee is formed a short distance above Knoxville by the junction of the French Broad and Holston Rivers. The former has a total drainage area of 4,810 square miles. The indicated horse power along chosen sections of the French Broad River is set forth in Table 8.

TABLE 8.—*Indicated horse power developed by French Broad River.*

Section of river.	State	Length.	Mean drainage area.	Minimum discharge.	Minimum discharge during 6 high-water months.	90 per cent total fall.	Minimum horse power.	Minimum horse power during 6 high-water months.	Horse power available from storage during a period of—		
									12 months.	6 months.	3 months.
French Broad Riv. From mouth to Nolichucky River	Tenn.	Mi. 64	Sq.Mi. 4,430	Sec.ft. 2,440	Sec.ft. 3,900	Feet. 135	30,000	48,000	Submerged		
From Nolichucky River to Pigeon Riv.	Tenn.	4	2,260	1,360	2,180	4.5	555	888	None.	None.	None.
From Pigeon River to Swannanoa River	T.-N.C.	64	1,750	1,220	1,950	828	91,800	147,000	None.	None	None.
From Swannanoa River to East Fork	N. C.	33	440	440	704	180	7,200	11,500	None.	None.	None.
From East Fork to West Fork	N. C.	2	66	99	158	9	.81	130	None.	None.	None.
From West Fork to head	N. C.	12	*36	54	86	†710	3,480	5,570	None.	None.	None.
Total							133,116	213,088			

*Total area. †Mean Head.

TRIBUTARIES OF THE FRENCH BROAD RIVER.

Little Pigeon River, in Tennessee.—This river is 30 miles long and has a total drainage area of 373 square miles. In the first 5 miles of the river, there is a fall of 50 feet, which, with the minimum discharge of 213 cubic feet per second, will give an indicated minimum horse power of 871. This part of the course would be submerged by the proposed French Broad reservoir. In the 25 miles above this first section, there is a total fall of 1,900 feet. Considering 480 feet of this as a reasonable working head, and a minimum discharge of 136 cubic feet per second, there is an indicated horse power of 5,930. West Fork of Little Pigeon River has a drainage area of 142 square miles and a total fall of 1,500

feet in 21 miles. Considering 380 feet as the available working head, and 99 cubic feet per second as the minimum discharge, there is a minimum indicated horse power of 3,420.

Nolichucky River in Tennessee is an important tributary of French Broad River, having a drainage area of 1,760 square miles. The indicated horse power along this river and tributaries is given in Table 9.

TABLE 9.—*Indicated horse power developed by Nolichucky River and tributaries.*

Section of river	State	Length.	Mean drainage area.	Minimum discharge.	Minimum discharge during 6 high-water months.	90 per cent total fall.	Minimum horse power.	Minimum horse power during 6 high-water months.	Horse power available from storage during a period of—		
									12 months.	6 months.	3 months.
Nolichucky River: From mouth to Greenville Station	Tenn.	Mi. 48	Sq.Mi. 1,450	Sec. ft. 768	Sec.ft. 1,230	Feet 180	12,600	20,200	8,360	16,720	33,440
From Greeneville Station to Toe Riv., Cane Cr.	T.-NC	48	880	484	774	*684	30,100	48,100	6,280	12,560	25,120
Toe River, from mo. to North Toe River and Sou. Toe River	N. C.	19	360	216	346	277	5,440	8,710	-------	-------	-------
North Toe River, from mou. to head	N. C.	41	o188	113	181	†510	5,240	8,380	-------	-------	-------
Lick Creek, from mouth to head	Tenn.	30	o262	157	251	†70	1,000	1,600	-------	-------	-------
Cane River, from mouth to Hinton Creek	N. C.	15	124	87	139	387	3,060	4,900	-------	-------	-------
Cane River, from Hinton Creek to head	N. C.	20	o64	45	72	†550	2,250	3,600	-------	-------	-------
North Indian Creek, from mouth to head	Tenn.	14	o70	42	67	†360	1,375	2,200	-------	-------	-------
Total							61,065	97,690	14,640	29,280	58,560

*Fall reduced to 150 feet by proposed reservoir. oTotal area. †Mean head.

Pigeon River is another important tributary of the French Broad, having a total drainage area of 667 square miles. The indicated horse power along chosen sections of this stream and tributaries is set forth in Table 10.

TABLE 10.—*Indicated horse power developed by Pigeon River and tributaries.*

Section of river.	State	Length.	Mean drainage area.	Minimum discharge.	Minimum discharge during 6 high-water months.	90 per cent total fall.	Minimum horse power.	Minimum horse power during 6 high-water months.	Horse power available from storage during a period of—		
									12 months.	6 months.	3 months.
Pigeon River:											
From mouth to Cataluchee Creek	Tenn.	Mi. 35	Sq.Mi. 560	Sec.ft. 308	Sec.ft. 493	Feet. 504	14,100	22,600	.....	.....	.....
From Cataluchee Creek to Richland Creek	N. C.	15	312	187	299	720	12,200	19,600	.....	.....	.....
From Richland Creek to West Fork	N. C.	7	155	124	198	207	2,330	3,730	.....	.....	.....
Cataluchee Creek, from mouth to head	N. C.	10	*62	43	69	o700	2,740	4,380	.....	.....	.....
Jonathan Creek, from mouth to head	N. C.	16	*65	46	74	o700	2,930	4,690	.....	.....	.....
West Fork, Pigeon River, from mouth to head	N. C.	14	*62	50	80	o400	1,820	2,910	.....	.....	.....
Total							36,120	57,910	.....	.....	.....

*Total area. oMean head.

The minimum indicated horse power on other important tributaries of the French Broad is given in Table 11.

HOLSTON RIVER

Holston River, all in Tennessee, has a drainage area of 3,750 square miles, and is 142 miles long from its mouth up to the junction of North and South forks. In the lower 102 miles of the stream the fall is only 254 feet, or a little more than 2 feet per mile. In case the proposed Holston reservoir were constructed the fall would be reduced to 75 feet. The minimum indicated horse power produced is 27,400. In the remaining 40 miles, from Rogersville Station to the mouth of North and South forks, there is a fall of 106 feet, and the minimum indicated horse power here is 9,720, or 14,600 for the 6 highest months.

SOUTH FORK, HOLSTON RIVER.

South Fork is far more important a tributary than the North Fork, and has a total drainage area of 2,040 square miles. The indicated horse power along several sections of this stream is set forth in Table 12.

TABLE 11.—*Indicated horse power developed on other importan. tributaries of French Broad River.*

Section of river.	State	Length.	Total drainage area.	Minimum discharge.	Minimum discharge during 6 high-water months.	90 per cent total fall.	Minimum horse-power.	Minimum horse-power during 6 high-water months.	Horse-power available from storage during a period of—		
									12 months.	6 months.	3 months.
		Mi.	Sq.mi.	Sec.ft.	Sec.ft.	Feet					
Spring Creek, from mouth to head ..	N. C.	16	72	43	69	*730	2,850	4,560	.....	.....	.....
Laurel Creek, from mouth to head ..	N. C.	23	134	80	128	*760	5,530	8,850	.....	.....	.....
Ivy River, from mo to Bull Creek....	N. C.	2	o160	112	179	90	918	1,470	.....	.....	.....
Ivy River, from Bull Cr. to West Fork	N. C.	2	o110	77	123	180	1,260	2,020	.....	.....	.....
Turkey Creek, from mouth to head ..	N. C.	15	79	55	88	*350	1,750	2,800	.....	.....	.....
Swannanoa River, from mouth to North Fork.....	N. C.	18	o90	63	100	207	1,190	1,900	.....	.....	.....
Hominy Creek, from mouth to head.....	N. C.	19	100	70	112	*210	1,340	2,140	.....	.....	.....
Mills River, from mouth to North Fork, South Fork.....	N. C.	5	o71	88	141	90	720	1,150	.....	.....	.....
North Fork, Mills River, from mouth to head ..	N. C.	8	24	29	46	*270	712	1,140	.....	.....	.....
South Fork, Mills River, from mouth to head ..	N. C.	....	43	60	96	*570	3,110	4,980	.....	.....	.....
Little River, from mouth to head .	N. C.	17	60	72	115	*400	2,620	4,190	.....	.....	.....
Davidsons River from mouth to head.	N. C.	13	42	59	94	*550	2,950	4,720	.....	.....	.....
West Fork, from mouth to head ..	N. C.	10	30	42	67	*350	1,340	2,140	.....	.....	.....
Total.....	.....	.....	.....	.....	.....	.....	26,290	42,060	.....	.....	.....

*Mean head. oMean drainage area.

Tributaries of South Fork.—Watauga River has a drainage area of 841 square miles. The indicated horse power along this river is set forth in Table 13.

Middle Fork is a tributary of the South Fork, having a drainage area of 231 square miles. Along the lower 19 miles of its course the fall is 150 feet and the minimum discharge 95 cubic feet per second, producing a minimum indicated horse-power of 1,170, and a minimum for the 6 highest months of 1,760.

White Top Creek, a tributary of South Fork, has a drainage area of 178 square miles. The fall in the lower 5 miles is 300 feet and the minimum discharge 72 cubic feet per second. There is produced a minimum indicated horse power of 1,760, and for the 6 highest months 2,650.

TABLE 12.—*Indicated horse power developed by South Fork of Holston River.*

Section of river.	State	Length.	Mean drainage area.	Minimum discharge.	Minimum discharge during 6 high-water months.	90 per cent total fall.	Minimum horse power.	Minimum horse power during 6 high-water months.	Horsepower available from storage during a period of—		
									12 months	6 months	3 months
South Fork, Holston River:											
From mouth to Watauga River	Tenn.	Mi. 18	Sq. mi. 1,940	Sec.ft. 776	Sec.ft. 1,160	Feet. 90	6,340	9,540	.....	.....	.....
From Watauga River to Middle Fork	T.-Va.	44	780	273	410	450	11,200	16,700	.....	.....	.....
From Middle Fork to White Top Creek	Va.	4	350	122	183	90	999	1,490	.....	.....	.....
From White Top Creek to head	Va.	32	*165	58	87	o350	1,850	2,780	.....	.....	.....
Total	.....	.....	.....	.....	.....	.....	20,389	30,510	.....	.....	.....

*Total area. oMean head.

TABLE 13.—*Indicated horse power developed by Watauga River and tributaries.*

Section of river.	State	Length.	Mean drainage area	Minimum discharge.	Minimum discharge during 6 high-water months.	90 per cent total fall.	Minimum horse power.	Minimum horse power during 6 high-water months.	Horse power available from storage during a period of—		
									12 months.	6 months.	3 months.
Watauga River:											
From mouth to Doe River	Tenn.	Mi. 20	Sq. Mi 760	Sec.ft. 418	Sec.ft. 627	Feet. 180	6,840	10,300	.....	.....	.....
From Doe River to Roan Creek	Tenn.	18	484	266	399	284	6,860	10,300	.....	.....	.....
From Elk Creek to Cove Creek	T.-N.C.	18	135	74	111	702	4,720	7,090	.....	.....	.....
Doe River:											
From mouth to Laurel Creek	Tenn.	6	127	64	96	225	1,300	1,960	.....	.....	.....
From Tiger Creek to head	Tenn.	14	*65	32	48	o670	1,950	2,920	.....	.....	.....
Laurel Creek, from mouth to head	Tenn.	12	*28	14	21	o850	1,080	1,620	.....	.....	.....
Stony Creek, from mouth to head	Tenn.	14	*54	32	48	o430	1,250	1,880	.....	.....	.....
Roan River, from mouth to Doe Creek	Tenn.	5	160	96	144	90	783	1,170	.....	.....	.....
Roan River, from Doe Creek to head	Tenn.	19	*109	65	98	o380	2,250	3,375	.....	.....	.....
Elk Creek, from mouth to head	T.-N.C.	24	*80	48	72	o770	3360,	5,040	.....	.....	.....
Total	.....	.....	.....	.....	.....	.....	30,393	45,655	.....	.....	.....

*Total area oMean head.

TABLE 14.—*Indicated horse power developed by other and lesser tributaries of the Tennessee River.*

Stream.	State	Length.	Mean drainage area.	Minimum discharge.	Minimum discharge during 6 high-water months.	90 per cent total fall.	Minimum horse power.	Minimum horse power during 6 high-water months.
		Mi.	Sq.mi.	Sec. ft.	Sec.ft.	Feet		
Duck River from Columbia to head	Tenn.	100	600	90	240	360	3,110	8,290
Elk River from Fayetteville to head	Tenn.	60	400	100	240	270	2,590	6,220
Sequatchie River from mouth to Dunlap	Tenn.	32	410	102	246	90	882	2,120
Sequatchie River from Dunlap to head	Tenn.	30	150	38	90	180	656	1,450
N. Chickamauga Creek	Tenn.	20	60	18	36	810	1,330	2,650
Soddy Creek	Tenn.	12	35	11	22	900	900	1,800
Roaring Creek	Tenn.	15	60	18	36	900	1,470	2,940
Piney Creek	Tenn.	16	65	20	40	900	1,640	3,270
White Creek	Tenn.	15	75	22	44	900	1,800	3,600
Total								32,340

TABLE 15.—*Indicated horse power developed by tributaries of the Cumberland River.*

Stream	State	Length.	Mean drainage area.	Minimum discharge.	Minimum discharge during 6 high-water months.	90 per cent total fall.	Minimum horse-power.	Minimum horse-power during 6 high-water months.
		Mi.	Sq. mi.	Sec. ft.	Sec. ft.	Feet		
Caney Fork from Cumb. River to Collins River	Tenn.	80	2,000	800	1,600	234	17,000	34,000
Caney Fork from Collins Riv. to head	Tenn.	30	375	150	300	450	6,140	12,300
Collins River	Tenn.	45	350	140	280	270	3,440	6,880
S. Cumb. Riv. from mouth to Clear Fk.	Tenn-Ky	70	1,000	300	600	360	9,810	19,600
New River	Tenn.	50	195	78	156	450	3,190	6,380
Clear Fork	Tenn.	30	140	56	112	450	2,290	4,580
Total							41,870	83,740

Difficulty of separating power within from that without the State.—A scrutiny of these tables will show how difficult it is to separate the quantity of power susceptible of development strictly within the State from that shown for the various sections of the diverse streams which cross State boundaries. Thus, for example, table 8 shows the minimum horse power which may be developed during the six high water months on the French Broad River from the confluence of the Big Pigeon to that of the Swannanoa River to be 147,000 horse power. By storage this could probably be increased to 180,000 horse power. The length of river considered is 64 miles. Of this approximately 26 miles lies within Tennessee and 38 miles within North Carolina. The power capable of develop-

TABLE 16.—*Indicated horse power developed by minor streams of the State, not included in previous tables.*

Stream	Tributary to	Section		Length.	Mean Drainage Area.	Minimum Discharge	Minimum discharge during six high water mos.	90 per cent of total fall	Minimum horse power	Minimum horse power during six high water months
		From	To	Mi.	Sq. Mi.	Sec. ft.	Sec. ft.	Ft.		
Sylco Creek	Ocoee River	mouth	head	7	12	13	21	360	173	277
Greasy Creek	Ocoee River	mouth	head	7	26	28	45	270	438	701
Big Creek	Ocoee River	mouth	head	6	14	15	24	630	364	582
Brush Creek	Ocoee River	mouth	head	7	18	20	32	360	378	605
Pototo Creek	Ocoee River	mouth	head	7	15	16	26	450	349	558
Spring Creek	Hiwassee River	mouth	head	12	37	28	45	900	975	1,560
Lost Creek	Hiwassee River	mouth	head	7	21	16	26	450	335	536
Coco Creek	Hiwassee River	mouth	head	11	21	16	26	720	655	1,050
Turtletown Creek	Hiwassee River	mouth	head	9	35	26	42	630	1,300	2,080
Bent Creek	Nolichucky River	mouth	head	13	36	22	35	180	160	256
Little Chucky	Nolichucky River	mouth	head	16	46	28	45	180	204	325
Big Limestone Creek	Nolichucky River	mouth	head	15	80	48	77	180	350	560
South Indian Creek	Nolichucky River	mouth	head	14	85	51	67	630	1,160	1,860
Turkey Creek	French River	mouth	head	15	79	55	88	720	1,750	2,800
Stony Creek	Watauga River	mouth	head	14	54	14	21	1,350	1,080	1,620
Total										15,370

ment within Tennessee cannot be estimated on the basis of these distances. Again, the total fall within the reach of the river under consideration is 920 feet; that within Tennessee is approximately 270 feet, and the balance, or about 650 feet, lies within North Carolina. But the division of the available power cannot be approximated on the basis of these figures, since between the point where the river crosses the State line and the confluence of the Big Pigeon River there are a great many small tributaries, the discharge of which serves to swell that of the main stream; so the flow in Tennessee is larger than it is in North Carolina. A very approximate figure for the relative volumes of flow within the two states can be arrived at by a comparison of the relative drainage areas. The drainage area at the mouth of the Pigeon River is approximately 1,750 square miles; that at the crossing of the State line, 1,550 square miles, and that at the mouth of the Swannanoa 860 square miles. Therefore the mean drainage area in Tennessee is 1,650 square miles and in North Carolina 1,205 square miles. If therefore we assume that the conditions as to rainfall, forested area, geological formations, etc., which affect the run-off of a stream are essentially the same on both sides of the State line, we arrive at the conclusion that on the Tennessee side the minimum discharge during the six high-water months is in the

neighborhood of $\frac{1}{1}\frac{6}{2}\frac{5}{0}\frac{0}{8} \times 1950$ cubic feet per second, or 2680 cubic feet per second, and hence that Tennessee's proportion of the 147,000 horse power is 60,000 horse power.

It must be evident that this method of calculation admits of no very high degree of accuracy. Moreover the assumption that the minimum horse power which may be developed without storage during the six high-water months is the economic horse power of the stream is probably ultra-conservative. Thus, for example, the United States Geological Survey ascribes to the section of the Tennessee River from the "Pan" to Chattanooga a minimum horse power during the six high-water months of 38,900; yet the water power development at Hales Bar now completed will render 58,800 horse power available for all but two or three weeks of the year.

Minimum horse power for 67 per cent of the time.—The amount of power that can be developed for two-thirds of the days of the year on all of the rivers here considered, with one exception, is greater than the minimum for the six high-water months. In the case of some of the rivers it is 33 per cent greater. On the average for the streams of Tennessee it is 23 per cent. greater. Good engineering practice indicates that it is commercially feasible to develop a water power up to the point where for 60 per cent. of the time the river will yield water enough to run all of the installed wheels at their full capacity. If therefore we take as our final basis for summarizing the available water power resources of the State the quantities which can be developed for 67 per cent. of the time, we cannot be open to a charge of overstating the case.

The data of the United States Geological Survey do not afford this information directly for all the streams. The information which they do afford is given in Table 17. In table 18 we have brought together a summary from all the preceding tables of the minimum horse power available entirely withinTennessee (*without storage*) during the six high-water months. Then adding to the total of this quantity, 23 per cent., we arrive at our final estimate of the water power resources of Tennessee, namely, 1,020,000 horse power.

TABLE 17.—*Minimum horse power for 67 per cent. of the time.—Tennessee River drainage.*

	Length Miles	Minimum horse pow. six high wat. mos. 90%	Minimum horse pow. two-thirds of the time 90%
Hiwassee River above Ocoee River	82	97,300	103,000
Ocoee (and Toccoa) River	94	75,800	75,800
Tributaries of Ocoee (and Toccoa) River		14,100	14,100
Tributaries of Hiwassee River bel. Nottely		7,340	7,340
Clinch River		52,500	70,000
Powell River and tributaries		15,000	20,000
Tributaries of Clinch River above Powell		8,900	11,800
Little Tennessee River	134	181,000	204,000
French Broad River	179	212,000	265,000
Little Pigeon River and tributaries		14,900	18,500
Nolichucky River and tributaries		108,000	135,000
Pigeon River and tributaries		59,900	74,800
Holston Riv. and S. Fork of Holston Riv.	240	86,000	115,000
Watauga River and tributaries		50,400	67,200
Total		983,140	1,181,540

NOTE:—Minimum horse power for six high water months is lowest period in six highest months, that is, the minimum for the seventh lowest month. Minimum horse power for two-thirds of the time is the lowest amount for two-thirds of the total number of days in the year. Both of these are for the average year 1900 to 1906 inclusive.

TABLE 18.—*Summary of the water power available for development, without storage, wholly within Tennessee. Minimum horse power during the six high-water months.*

Stream	Location	Horse power
Tennessee River	Shellmound to Chattanooga	58,800
Tennessee River	Chattanooga to Knoxville	50,000*
Hiwassee River	From Ocoee Riv. to State line	69,490
Ocoee River	From mouth to State Line	55,230
Clinch River	From Emory Cr. to State Line	35,080
Powell River	From mouth to State Line	8,400
Little River	From mouth to source	4,190
Tellico River	From mouth to source	12,360
Little Tennessee River	From mouth to State Line	87,550
French Broad River	From mouth to State Line	60,000
Citico Creek	From mouth to source	4,000
Abrams Creek	From mouth to source	6,320
Little Pigeon River	From mouth to source	16,360
Nolichucky River and tributaries	From mouth to State Line	67,500
Pigeon River	From mouth to State Line	22,600
Holston River	From mouth to South Fork	56,000
South Fork Holston River	From mouth to State Line	13,500
Watauga River and tributaries	From mouth to State Line	39,800
Small tributaries of Tenn. River		32,340
Tributaries of Cumberland River		74,000
Minor additional Streams		15,370
Small water powers not considered by U. S. G. S.†		40,000
Total		828,890
Total available for two-thirds of the time		1,020,000

*The United States Geological Survey ascribes 175,000 horse power to the Tennessee River from Chattanooga to Knoxville; but inasmuch as the interests of navigation would not permit of the development of all of this power, this figure has been reduced to 50,000. According to the report of the Chief of Engineers of the United States Army, 20,000 horse power could economically be developed at a point about six miles from Knoxville.

†The writer has estimated the small water powers of the State capable of being developed by individual farmers in units of 25 horse power and less to total 75,000 horse power. (See "Resources of Tennessee," Vol. 1, No. 1.) For the purpose of this summary this figure has been reduced to 40,000 horse power.

POSSIBLE INCREASE IN POWER BY STORAGE

In Table 1 is presented the data of twenty suggested reservoir sites, located by the U. S. Geological Survey, and in tables 2 to 13 inclusive is shown the increase in power which these reservoirs would yield. Their locations are shown on the water power map. A little thought will make it evident that no real estimate can be made, on the basis of these reservoir sites, of the ultimate figure to which the water power resources of Tennessee will mount. Many of the sites are outside of the State. Were the reservoirs built, they would nevertheless increase the power which might be developed at all power sites lower down upon the respective streams, and hence would affect the Tennessee power resources. Even should the State fortunately adopt the most advanced and enlightened policy for dealing henceforth with its water powers, it would not be within its province to build these outside reservoirs. But many favorable reservoir sites within the State, not here indicated, are to be had.

The writer will not venture to place a figure on the ultimate water power resources of Tennessee. Probably, could this be done, the figure would lie between two million and three million horse power. Whether two million or three million, the quantity is sufficiently large to warrant the statement that among her possessions Tennessee has few more valuable than her water power.

It is in order to inquire how great would be the cost of developing two million horse power, and what would be the annual value of it, assuming it to be developed.

CAPITAL COST OF WATER POWER DEVELOPMENT AND VALUE OF WATER POWER

It is not possible for the Survey to state what will be the cost of developing any one of the water powers of the State. It has had no opportunity to make the requisite investigation and study to enable it to do so. Nevertheless, a valuable service might be rendered by bringing together, from various sources of information, data as to the cost of developing water powers elsewhere.

The cost of water power development varies over a wide range. In general it is less per horse power for large than for small plants; less for high-head than for low-head developments. Yet the variation in conditions is so great that deductions of only the most general character can be drawn. To illustrate: The 15,500 horse power plant of the Chicago Sanitary District was built at a cost of about $225.00 per horse power. On the other hand, the writer has recently built a strictly first-class plant of only 110 horse power capacity at a cost of $50.00 per horse power, this cost including 1,100 feet of timber flume, power-house, twin turbines, governor, generator and switch board.

Some excellent cost data are supplied by the Hydro-Electric Power Commission of the Province of Ontario, Canada. In the first report of the Commission were given estimates of three possible power developments at Niagara Falls; the first to be of 50,000 horse power. capacity, the second 75,000, and the third 100,000. The capital cost of these plants would be respectively $114.00, $94.00 and $86.00 per horse power. The second annual report gives the costs of 25 Canadian plants, ranging in size from 500 horse power to 16,350 horse power; and the unit costs of these range from $203.00 to $50.00 per horse power. The total power to be developed by the 25 plants is 116,330, at a total cost of $10,236,000.00 or at an average cost of $88.00 per horse power.

Professor Daniel W. Mead in his work on "Water Power Engineering" gives two tables showing capital costs of water power developments, the one in Europe and the other in America. The

first comprises 17 plants in which a total of 180,000 horse power is developed at a total cost of $27,606,000, or an average unit cost of $153.00. The second comprises 11 American plants developing a total of 129,550 horse power at a total cost of $13,213,000.00; or a unit cost of $102.00 per horse power. This table includes the plant at Spiers Falls, N. Y., where 50,000 horse power is developed at a unit capital cost of but $42.00 per horse power.

The writer knows of a large Southern water power plant which was built for a unit cost of $97.00 per horse power.

Taking all of these figures into consideration, it seems certain that $100.00 per horse power is a liberal estimate of the average capital cost for which the water powers of Tennessee could be developed.

ANNUAL COST OF POWER

A matter of more general interest than capital cost is the consideration of the annual cost of power; by this is meant the total of interest on investment, taxes, insurance, depreciation and actual administration, maintenance and operating expenses. Upon the basis of the annual cost of producing water power, and upon this alone, can an appraisal of the value of the water power resources of the State rest.

From the reports of the Hydro-Electric Power Commission of Ontario, data covering 29 plants have been brought together. The combined capacity of the plants is 338,929 horse power measured either at the power house transformer terminals or at the terminals of the transmission lines, and the combined annual cost of the power as given is $3,142,388.00. The average cost per horse power per year is therefore $9.27. This figure includes the cost of long distance transmission in 5 of the 29 cases, and water rental amounting to $195,000.00 a year in three others. Deducting this last reduces the average cost to $8.70, and if the power transmitted in the five cases were measured at the power house switch board instead of being measured at the transformer terminals, the cost would be somewhat less than $8.50 per 24 hour horse power per year.

As a check upon the reliability of the average figures deduced in the preceding paragraph, it is of interest to note that the Hydro-Electric Power Commission of Ontario buys power of the Ontario Power Company of Niagara Falls in accordance with the following terms: For power at 12,000 volts the price for the first 25,000 horse power is $9.40 per horse power per year; beyond 25,000 horse power, $9.00 per horse power per year; for power at 60,000 volts, $10.40 per horse power per year up to a consumption of 25,000 horse power, and $10.00 for power in excess of this quantity. These prices return to the Company a fair profit, notwithstanding the rental which the Company pays to the Government for the use of the water.

Coming much nearer home, it may be stated with certainty that water power developed in our own section of the country is trans-

mitted for a distance of nearly one hundred miles, and sold (to large consumers) at a satisfactory profit for about 5½ mills per horse power hour. This price, figured on a basis of 10 hours a day for 310 working days a year is equivalent to $17.05 per horse power per year. The writer is not advised how large a profit this figure includes; but it is probable that the actual cost of generating this power, measured at the switch board of the generating station, does not exceed $9.00 per horse power per year.

By way of conclusion, the writer estimates that a comprehensive scheme for the progressive development of the entire water power resources of the State could be consummated at an average cost not to exceed $11.00 per horse-power per year, measured at the switch board.

The cost of building transmission lines, including the cost of right of way, is very closely $3,000.00 a mile. Let us assume then that the complete system of power development and transmission covering the entire State is to be considered. It is probable that the *average* distance to which power would be transmitted would not exceed 50 miles; for altho a part of the power might require to be transmitted for a distance of 400 miles, by far the larger bulk of the power would be consumed in the immediate neighborhood of the power plants; and 50 miles would seem to be a fair average length of transmission. If we assume that the power capacity of each transmission line is 25,000 horse power, and assume a loss in transformation and transmission of 8 per cent, thus charging against the power this loss together with interest on, and depreciation and maintenance of transmission lines (figured at 15 per cent.), we should add to the cost of producing the power, $1.00 per horse power per year for transmission, making the total cost of power, delivered to the step-down transformers $12.00 per horse power per year.

Finally, a proper basis for valuing the water power resources of the State is to be secured by comparison with the cost of generating steam power from coal.

THE COST OF STEAM POWER

There are few cities in the United States in which power may be generated from coal as cheaply as in Knoxville. Here coal may be bought on large contracts for $1.30 per ton delivered on the side track of the consumer. Moreover, labor in Knoxville is cheap. The writer has knowledge of a large industrial plant in which the cost of power delivered to the countershaft is only $24.00 per horse power per year, this price including interest at 6 per cent, depreciation 8 per cent, insurance and taxes 4 per cent, besides coal oil and labor. The plant is unusually fortunate in having access to condensing water, without cost. He is familiar with another plant in which the management makes the claim that steam power costs but $13.00 per horse power per year. But this figure is unreliable, because it neglects the overhead charges, and moreover is based upon indicated and not delivered horsepower. The actual cost at this plant cannot be less than $25.00 per horse power per year. A third and smaller plant may be cited, having a capacity of 300 horse power, in which the cost is $45.00. These are all plants in which the load upon the engine is remarkably constant, which fact in part accounts for the low costs cited.

In the Report on the "Survey of the Tennessee River" by the Corps of Engineers, U. S. A., Major Wm. H. Harts, in discussing the possible value of a water power development on the Tennessee River near Knoxville, states: *

> "The cost of steam power generated from coal in the vicinity of Knoxville is believed, from the best information available to be about $35.00 per horse power-year in economical plants of large size. In cotton mills in Northern Alabama the cost is said to be as low as $15.00, but ordinarily it runs from $40.00 to $200.00 in installations of moderate size. It is doubtful, however, if electricity could be sold for more than $45.00 in competition with steam. In the Engineering News of January 8, 1903, (p. 30), $20.00 and $40.00 are taken as the limits for the charges per electrical

*House Document No. 360, 62nd Congress, 2nd Session.

> horse power per year delivered to the customer; and charges on several contracts in Chattanooga are understood to be on a $40.00 basis for ordinary use."

Comparing the cost of electric power produced from water power and from steam, Major Harts writes further:

> "From these data it would seem that in the general case there would be a difference of about $16.00 per horse power year between the cost of producing electric power from water under favorable conditions and that of producing it from steam."

While the costs of steam power given above represent current American practice, in which real economy is not attained, there are two relatively new types of power plant now available, by means of which the cost of steam power can be greatly reduced below the figures above cited. The steam turbine is one of these. Steam turbines are now built in very large sizes, and these large machines attain quite high economy. It is probable that the steam turbine equipment, say for 20,000 horse power, could be installed in a plant located at the mouth of some one of the coal mines in East Tennessee and generate electricity for transmission to the larger cities at a cost considerably below that at which power is now being sold. Power thus developed could be delivered to a substation in Knoxville for about $9.00 per horse power per year.

The second new type referred to is the poppet valve engine utilizing high pressure and high degrees of superheat in the steam. This type of engine was perfected in Germany, and for the past five or six years has been rapidly replacing the older types of engines throughout Europe. It is now beginning to receive the attention in this country which it deserves. The engines are made in sizes up to 2,000 horse power; but a striking fact concerning them is that the small engines develop as high efficiency as the large. Whereas in our common practice from three to five pounds of coal are consumed per horse power per hour, these new units generate a horse power hour with the consumption of but 1.5 pounds of coal if run non-condensing, and if condensing with a consumption of about one pound. Several thousand of these plants are in successful operation in Europe. Their introduction into America has begun; and it is certain that within another

decade they will have revolutionized American steam power plant practice. Could the new type of steam plant come immediately into universal use, the cost of steam power would be reduced to less than half its present figure. But no such radical step will be taken; and in the meantime the demand for power grows at so prodigious a rate that on the whole the cost of steam power may be expected to advance rather than recede.

> "From 1870 to 1910 the population of this country increased from 38,000,000 to 92,000,000, or more than 142 per cent, and the coal consumption increased per capita from 0.85 tons to 5.50 tons, or almost 550 per cent; hence in forty years the coal consumption has increased about forty times as fast as the population. During this interval the average value of coal property has increased from $100.00 to $2,000.00 per acre, or 1,900 per cent., which is nearly four times the rate of consumption increase. When it is remembered that this phenomenal change in volume and value has been accompanied by a corresponding wage increase and more difficult engineering work in connection with the greater depth of the mines, it is a tribute to our application of scientific management in both mine working and transportation that we are not paying several hundred per cent. more for coal at this date than we are; but, coming events cast their shadows before' and the abnormal rise in mine values, together with the continual labor agitation, makes it almost certain that within a short period the cost of coal at the mines will be increased from 25 to 50 per cent., and that a greater proportionate increment of cost will be added as the coal passes the several go-betweens in its transit from the mine to the ultimate consumer."*

If in view of the possible reduction in the cost of steam power which better economy could effect, we abandon the basis of comparison deduced by Major Harts and quoted above, and claim for water power a difference not of $16.00 but of $10.00 per horse power per year, we shall conclude that the present potential value of the water power of Tennessee is $10,000,000.00 per year. The future potential value is great beyond our present ability to surmise.

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*Second Annual Report of Main State Water Storage Commission, page 232.

THE PRESENT DEVELOPMENT OF WATER POWER IN TENNESSEE

General Statement.—The writer has made an effort to take a census of the developed water powers of the State, but without avail. To this end a letter was addressed to the Register of each county, enclosing a blank to be filled out, giving the number and locations of water wheels in operation within the county. Replies were received from fewer than half of the gentlemen addressed, and of the replies received, only a few contained any reliable information.

According to a special water power census taken in 1908 by the United States Census Bureau, there were at that time 2,160 water wheels in operation in the State, the distribution and horse power developed being as follows:

TABLE 19.—*Developed water powers in Tennessee for all purposes. 1908.*

	Wheels	Horse power
Tennessee River	1,691	85,548
Cumberland River	397	8,576
Green River	10	140
Mississippi River	62	796
Total	2,160	95,060

An average of 54 H. P. per wheel.

The above figures must include such water power developments as were used in generating electricity for electric light and public service corporations, since the census of 1910, Department of Manufactures, gives the following data on water power developed for strictly manufacturing purposes:

TABLE 20.—*Developed water power in Tennessee for manufacturing purposes.*

Year	1899	1904	1909
No. of Wheels	401	299	341
Total H. P.	11,078	9,762	9,670
Per cent of power used in mfg.	8.5%	5.6%	4.0%

This table would seem to indicate that the use of water power in manufacturing is declining, for while 8.5 per cent. of all the power thus used in the year 1899 came from water wheels, only 4 per cent. came from this source ten years later. Undoubtedly the explanation is found in the rapid expansion of commercial power business by the public service corporations. These can generate power in large quantities and sell electricity for the operation of manufactures more cheaply than the relatively small isolated power plants of the factories themselves can produce it.

The figures of this census emphasize in a startling manner the fact that the year 1912 marks the beginning of a new era in the history of water power development in Tennessee,—the era of hydro-electric development and of long-distance power transmission. During this year, seven water wheels, capable of developing 29,200 horse power were put into operation. To this number there were added during 1913 fourteen more wheels with a capacity of 63,600 horse power. Therefore the total present installed capacity of all the water power plants within the State is very close to 190,000 horse power. Four additional wheels with a capacity of 16,000 horse power remain yet to be installed in the power house at Hale's Bar; and during the year 1914 construction will begin on a plant of 80,000 horse power capacity on the Little Tennessee River.

Existing Plants.—Following are brief descriptions of a number of these developments. It is believed that no important development, either in progress or in prospect, is omitted from the list; yet this cannot be said with certainty, since the projectors of an enterprise of the nature and magnitude of hydro-electric developments are naturally reticent during the formative stages of their designs. Rumors of many projects abound, and the writer has spared no effort to sift these in order to ascertain which have any basis for credence. Thus, it is rumored that the American Zinc Co., which is now operating zinc mines at Mascot, has under contemplation the development of power on the Holston River. Writing of this, the company says: "This matter of power has been discussed tentatively, but it cannot in any way be considered a definite project at this time." Other rumors might be listed, but they are too tenuous to merit attention.

Mention should be made in passing of a project located on the Hiwassee River just across the State line, in Clayborne Co., North Carolina; the project of the Carolina Tennessee Power Co. The

PLATE IV.

VIEW OF OCOEE PLANT AT PARKSVILLE, SEPTEMBER, 1911, DURING CONSTRUCTION.

plans of this company are to build two plants, about 15 miles apart, which will have a combined rating of 50,000 horse power. Each dam will be 150 ft. high and 1,200 ft. long, and each will create a lake about 15 miles in length. The location is approximately 60 miles south of Knoxville, 55 miles east of Chattanooga and 100 miles north of Atlanta. Owing to this location, it is more than probable that the power will seek a market within Tennessee.

The Tennessee Power Company.—First in the order of importance at this time comes certainly the developments of the Tennessee Power Co. The following description of the organization and plans of the company is quoted from the "Electrical World," of April 13, 1912:

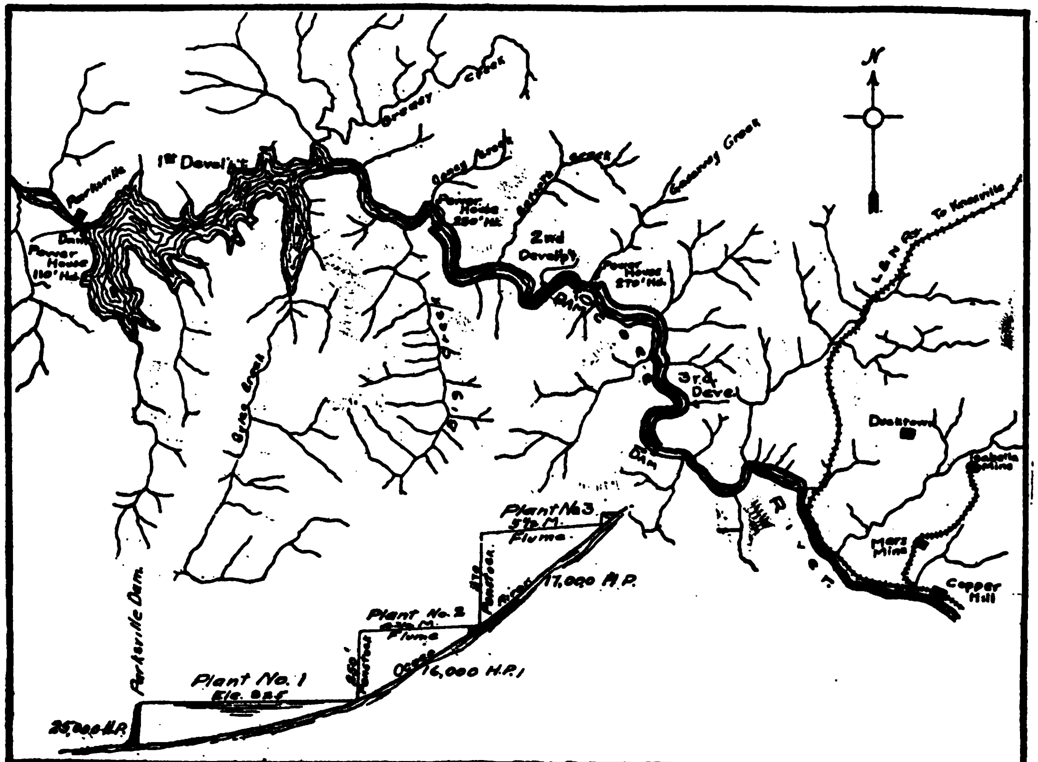
"Negotiations between H. M. Byllesby & Company, Chicago; E. W. Clark & Company, Philadelphia; William P. Bonbright & Company; and Hodenpyl, Hardy & Company, New York, have resulted in the formation of a plan for developing water power resources in the State of Tennessee and the transmission of energy throughout this State and Kentucky and parts of Georgia. The plan calls for the formation of the Tennessee Railway, Light and Power Company under Maine laws and the Tennessee Power Company under Tennessee laws. The authorized capitalization of the first company will consist of $50,000,000 preferred stock, of which $10,250,000 will be outstanding, and $20,000,000 common stock, all of which will be outstanding.

"The capitalization of the Tennessee Power Company will consist of $50,000,000 first-mortgage, fifty-year 5 per cent gold bonds, dated May 1, 1912, of which $7,500,000 will be outstanding, and of $20,000,000 common stock, all of which will be issued. The Tennessee Railway, Light and Power Company will own the following: All of the capital stock of the Tennessee Power Company (excepting the qualifying shares of the directors); a large majority and probably all of the common stock of the Nashville Railway & Light Company; all the bonds and capital stock (except directors' qualifying shares) of the Cleveland Electric Light Company, of Cleveland, Tenn.; a large majority and probably all of the preferred and common stock of the Chattanooga, Railway & Light Company. The company will have approximately $882,000 in its treasury as working capital. The Tennessee Power Company will own, free from all encumbrances (other than its first-mortgage bonds mentioned above), the following

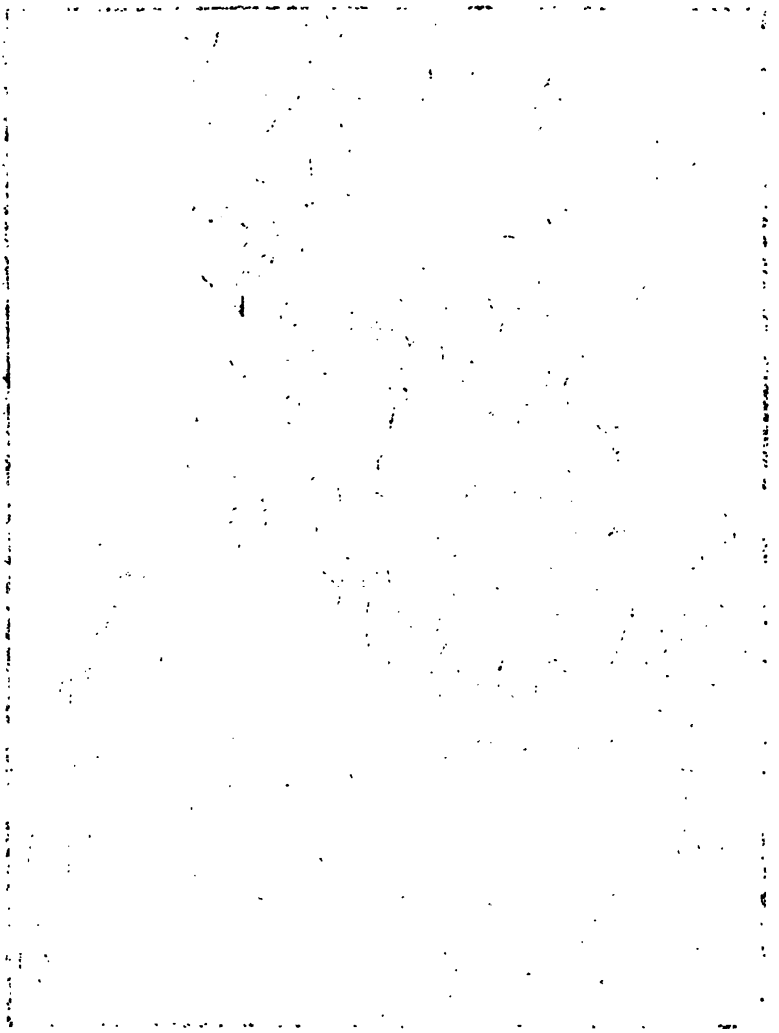
properties: The 25,000 horse power hydro-electric plant on the Ocoee River at Parksville, Tenn., now in operation; the transmission lines now in use from this plant, by way of Cleveland, to Chattanooga; the transmission line from Cleveland to Knoxville, Tenn., which is nearly completed; the transmission line from Cleveland southward to the Georgia State line; the Great Falls power site and reservoir at the junction of the Caney Fork and Collins Rivers, near Rock Island, Tenn., capable of development of 80,000 horse power, and said to be the most desirable water power site in Tennessee; two sites on the Ocoee River, in addition to the first named above, one capable of development of 16,000 horse power and the other of 30,000 horse power. The company will have in its treasury $2,478,000, which it is proposed to use for new construction and other corporate purposes. A large part of the properties named above will be acquired by purchase from the Eastern Tennessee Power Company, with the approval of the stockholders of that company. The following construction work will be undertaken immediately by the company: An addition of 15,000 horse power to the first development on the Ocoee River, now in operation as above; construction of a 16,000 hydro-electric plant on the second site on the Ocoee River, to operate under a 250-ft. head; construction of additional transmission lines fromParksville, by way of Great Falls, to Nashville, Tenn., and from Nashville through the surrounding country, to reach the various power users."

The second development on the Ocoee River referred to is now completed and work on the third is about to begin. In addition to this, an engineering party is now in the field to locate a suitable site for a storage reservoir on the headwaters of the Ocoee. A detailed description of the first project by the writer appears in No. 2 of Vol. 2 of "The Resources of Tennessee," also another in an article entitled "Water Power Development in the South" in Cassier's Magazine for June and July, 1912.

The accompanying map and profile (Plate III) show the nature of the three developments on the Ocoee River, and their relative locations. The dam of development No. 1 creates a lake about 8 miles long; at the head of this lake is located the power house of development No. 2. Water for this development is diverted from the river by a timber crib dam, 30 feet high, situated some miles higher on the river; the water is then conveyed in a timber flume about 4¾ miles long laid on a very light grade to the site of the power house,



MAP AND VIRTUAL PROFILE SHOWING DEVELOPMENT OF THE TENNESSEE POWER COMPANY ON OCOEE RIVER.



where it discharges into the steel penstocks. The end of the flume is at an elevation of approximately 270 feet above the bed of the stream, and this head will be utilized by the turbines. The third development is similar in character to the second, but the flume will be 5½ miles long.

Since April, 1912, the Tennessee Power Company has been furnishing all the electric power for the city of Chattanooga, and since October, 1912, that for Knoxville. The transmission line to Knoxville extends on to Mascot to supply the American Zinc Company with power for its mining operations. The line to Nashville was completed in June, 1913. The Aluminum Company of America has contracted to take a block of 20,000 horse power, beginning on June 1st, 1913, for a minimum period of five years. At the present writing, the people of both Knoxville and Chattanooga are most curious to know which of the transmission lines is destined to carry this load.

The Tennessee Power Company is the first great power company to become domiciled in the State. In view of the history of centralization of power development in other states, and particularly in view of the connections of the men who have formed the Tennessee Power Company, it is difficult to avoid the supposition that this wealthy corporation purposes to dominate the power situation in this section of the South. The report of the U. S. Commissioner of Corporations, referred to elsewhere in this bulletin, shows that the owners of this company are the owners also of a large number of water power developments and of numerous public service corporations (to the number of not less than 43) in various parts of the country. Not only this, but through their common memberships in the directorates of certain other corporations, the Tennessee Power Company is allied to the General Electric Company itself. And if it be true, as many believe, that a power trust is already in existence or is in process of formation then, unless it be checked very soon, Tennessee is not likely to escape its dominance.

The Hale's Bar Development.—Next in immediate importance to the development of the Tennessee Power Company, comes the plant of the Chattanooga and Tennessee River Power Company, recently completed at Hale's Bar, on the Tennessee River. As an engineering accomplishment, this plant will take rank among the foremost projects of the day. Located 21 miles be-

low Chattanooga by road—33 miles as the river winds, and but thirteen as the crow flies—at the lower end of what is termed the "mountain section" of the Tennessee River, the forty foot dam will back the river up for a distance of 38 miles, and will convert this section of the river from one of hazardous navigability into a lake of serene tranquility, wonderful beauty and entire safety to navigation.

The power equipment will comprise fourteen units, each consisting of three turbines and the generator mounted upon a vertical shaft, and developing 4200 horse power each. Thus the capacity of the plant will be 58,800 horse power. Ten of these units are now installed.

The total length of the dam, including the lock, is 2500 feet. Beginning at the western embankment, we have first the lock, in which the lock chamber measures 60 feet wide by 312 feet long; next, the concrete spillway measuring 1200 feet in length; then the power house 350 feet long, and to the east of this an 800-foot earth dam built over a concrete core-wall. At times of extreme flood, there will be a larger volume of water flowing over this dam than over any other dam now existing in the world. Some interest attaches to the lock also, because it is the highest single lift lock in the world. The great lock gates measure 58 feet in height, and they will be operated by electric motors.

Construction was begun in October, 1905, with the expectation that three or four years would suffice for the completion of the project. However, unforseen difficulty was experienced in obtaining suitable foundation, and this greatly retarded the progress of the work. On Nov. 13, 1913, the completion of the plant was officially announced, and in the presence of a distinguished party, the turbines were placed in operation. A transmission line to Chattanooga and a sub-station in that city were built some three years ago, and there is some talk of building a transmission line to Birmingham.

For further details regarding the Hale's Bar development, the reader is referred to a paper by the writer in Vol. 2, No. 3, of "The Resources of Tennessee," published by the Survey, or to the article by him on "Water Power Development in the South," in Cassier's Magazine, previously referred to.

The dam is building under a grant from Congress which gives the Company the use of the power for a term of 99 years. The Chattanooga and Tennessee River Power Company was the property

PLATE VI.

HALE'S BAR DAM, UNDER CONSTRUCTION, LOOKING WEST FROM THE END OF THE POWER HOUSE, NOVEMBER, 1911.

of the late Mr. Anthony N. Brady, of New York. Hence, it belongs in the group of properties known as the "Brady interests," and according to the United States Commissioner of Corporations, is, like the Tennessee Power Company, indirectly allied to the General Electric Company.

Watauga Power Company. The first development of the Watauga Power Company was completed in September, 1911, and it was the first large hydro-electric plant to go into operation in Tennessee. The plant is situated on the Watauga River, about six miles above Elizabethton. The dam is of Cyclopean concrete, 50 feet high above low water. The spillway is 240 feet long, and during the probable heaviest flood discharge of the river the water will stand twelve feet deep on the crest of the dam.

The installation is designed to consist of three units, developing 1600 horse power each, but up to the present time only two of these have been placed. Electricity, generated at 2300 volts, is transmitted at 44,000 volts to Elizabethton and to Bristol. The power requirements of Elizabethton being moderate, the bulk of the power is taken to Bristol and is sold to the Bristol Gas & Electric Company.

In addition to this power site, the Company owns two others, one located higher up on the Watauga River, and one on the Doe River.

Very recently the Company has sold its entire plant to the Utilities Improvement Co., one of the subsidiary companies of Henry L. Doherty & Co., of New York. The Utilities Improvement Company, and the Cities Service Co., another of the Doherty holding companies, own a very large number of public service corporations in many parts of the country and are rapidly increasing these holdings. Probably next to the General Electric Co., they are the largest of the huge power corporations. They own the Bristol Gas & Electric Co.

Tennessee Eastern Electric Company.—This project is the latest of the developments now actually completed. It consists of a dam and power house on the Nolichucky River, nine miles south of Greeneville. The dam is built with foundation adequate for an ultimate height of 70 feet, but for the present the dam will be carried to a height of only 39 feet. The ultimate height will create a pool about nine miles long, and will develop approximately 16,000 horse power, four units being used. For the present, 3,600 horse power represents the total plant capacity.

The Company, of which W. U. N. Powellson, of New York City, is President; R. L. Warner, of Boston, Treasurer; and Amzi Smith, of Johnson City, Manager, has purchased the electric plants of Johnson City, Greeneville, and Jonesboro. These plants will give the company steam auxiliary power to the extent of 1800 horse power. The company proposes to furnish power to these three cities, and later to extend its field as power demands warrant. The water power plant went into operation in September, 1913.

In addition to these, there are a number of smaller plants in operation, but none having capacities beyond a few hundred horse power. Nearly all are private plants furnishing power for manufacturing purposes.

PROJECTED DEVELOPMENTS

The Tennessee Hydro-Electric Company.—We have called attention to the projected developments of some of the leading companies in the preceding section. The most notable of the projected developments are those of the Aluminum Company of America and of the Tennessee Hydro-Electric Company.

This last named Company, chartered on April 16, 1912, proposes to develop all of the power afforded by the Clinch and the Powell Rivers, both in Tennessee and in Virginia. The plan contemplates the erection of five dams, as follows: Dam No. 1, 40 feet high, across the Clinch River just above the mouth of the Emory River in Roan County; Dam No. 2, 60 feet high, on the Clinch River just above the Louisville and Nashville Railroad crossing in Anderson County; Dam No. 3, 150 feet high, on the Clinch River just above Island Ford and a short distance below the mouth of the Powell River between Anderson and Campbell Counties; Dam No. 4, 260 feet high, on the Powell River, 500 feet above the Southern Railway bridge, in Claiborne County; Dam No. 5, 260 feet high, on the Clinch River about two miles above the Southern Railway bridge, between Claiborne and Grainger County.

The elevation of the crests of dams Nos. 4 and 5 will be the same, and the dams will constitute a single development. That is to say, one of the dams, that on the Powell River, will be a diversion dam, and the water of the Powell River, will be diverted through a tunnel which will discharge just above dam No. 5 into the Clinch River. The power house located at No. 5 will then utilize the flow of both rivers, under the head of 260 feet thus rendered available. The writer is not advised as to the horse power to be installed at each of these four power houses, but the company claims that their total development will aggregate 400,000, horse power. For the realization of any such total as this, it will be essential for the company to build storage reservoirs to impound the flood waters of the streams, and by this means equalize the flow.

The officers of the Tennessee Hydro-Electric Company are: President, J. R. Paull, of Pittsburg, Pa.; Vice-President and General Council, James B. Cox, of Knoxville; Treasurer and Chief

Engineer, F. M. Butler, of New Castle, Pa.; Secretary, J. R. Cox, of Knoxville. The Company is capitalized for $10,000.00; and the same men have incorporated the Virginia Hydro-Electric Company, with the same capitalization, in order that the right of eminent domain may be exercised in both States. The plans contemplate an expenditure of $20,000,000.00. Condemnation proceedings for securing riparian holdings have been instituted; but although plans and specifications are said to have been completed, actual work of construction is held in abeyance pending a decision on the right of the company to dam the Clinch River. A federal bill granting this right was introduced into the last session of Congress, but when it became known that President Taft would veto the water power bills that came to him for his action, this bill was withdrawn. It is the purpose to re-introduce the bill at the next session of Congress, but in the light of the decision of the Secretary of War with reference to the French Broad River, cited in the description below of the French Broad River Power Company, page 77, it would scarcely seem probable that the authority of Congress extends to the Clinch River.

It is commonly rumored that the Tennessee Hydro-Electric Company expects to market its power in Cincinnati or some other northern city. The writer is not advised as to the truth of this rumor, but it would certainly be more fortunate for Tennessee if a market for the power were to be found, or if not found, created, within our own boundaries.

The Aluminum Company of America.—For some months past the Aluminum Company has been busy acquiring title to all the power rights and riparian privileges on the Little Tennessee River, from Franklin, N. C., a distance of 65 miles, to a point 20 miles south of Maryville, Tenn., where the river finally emerges from the Unaka Mountains, and exchanges the vigor of a mountain stream for the more quiet flow of a mature river. In addition to this the company has acquired the tributary streams—the Cheoah, the Tuckaseegee and the Nanahala rivers. Complete surveys of this great water power holding have been made, and the sites of power houses and storage reservoirs have been practically determined. The ultimate plan contemplates the construction of dams, one beyond another, so placed that each will back water nearly or quite up to the toe of the dam next above it. Some of these dams, owing to the steep and narrow character of parts of the river bed, will impound but small quantities of water; while others, more

favorably situated for storage purposes, will form lakes of large extent. For instance, at one point on the Cheoah River a dam 135 feet high will impound about three and a half billion cubic feet of water. There are a number of fortunate reservoir sites, and the ultimate development now projected will not only utilize practically all of the fall of the streams (about 1,200 feet on the Little Tennessee River alone), but will to a very large extent conserve the flood waters of spring to spread them over the dry months of summer, and thus develop in an ideal manner the total power of all the annual stream run-off. This power will exceed 400,000 horse power.

The Aluminum Company of America, by purchasing the stock of the Knoxville Water and Electric Power Company, has acquired a franchise for furnishing light and power in Knoxville. However, furnishing light and power in Knoxville will be of secondary importance to this company, for its chief purpose is to erect reduction works for the production of aluminum from the mineral bauxite.

Construction on some of the dams would probably have been started some months ago except for a difficulty that arose over the interference of the water power development with the proposed Murphy extension of the Southern Railway. For months parties of engineers representing the aluminum company and the railway have been at work in an effort to make a satisfactory relocation of the railroad line. This matter has now been settled presumably to the satisfaction of both parties, and hence the way has been cleared for construction of the hydro-electric plants to proceed. The first of these plants to be built will be No. 2 (the numeral signifying that the plant will be the second, in point of location, as one proceeds upstream). It will be located near the mouth of the Cheoah River, in North Carolina. The dam will be approximately 200 feet high, and the plant will develop about 80,000 horse power. Dam No. 1, to be located about 5 miles lower down the river, will be the only one of the series situated within Tennessee. In dimensions it will resemble No. 2.

French Broad River Power Company.—This Company, incorporated in 1908, proposes to develop 30,000 horse power at a site on the French Broad River, just above its confluence with the Holston, distant from Knoxville but 5 miles. There are two sites under contemplation, about two miles apart, and some test drilling has been done to determine which of the two affords the more

favorable foundation. The company's plan contemplates the building of a dam 70 feet high. This will cause slack water up as far as Boyd's Creek, a distance of 22 miles. An interesting ruling by the United States War Department has been obtained by the Company. The ruling, dated May 5, 1909, is signed by Robert Shaw Oliver, Acting Secretary of War, and is as follows:

"I have today decided that the French Broad River is a navigable water of the United States, the navigable portion of which lies wholly within the limits of the State of Tennessee. Therefore, the charter granted by the Legislature of the State to this Company is sufficient authority to construct the dam in question, provided the location and plans thereof are submitted to and approved by the Chief of Engineers and by the Secretary of War before construction is commenced."

The company claims to have expended about $30,000.00 in preliminary examinations, the preparation of its plans and specifications, and the purchase of options riparian rights. At the present writing this project cannot be considered as more than a speculative holding, with no immediate prospect of active development.

THE DOE RIVER SURVEY

Before his resignation as State Geologist, Dr. George H. Ashley had effected a cooperative agreement with the Water Resources Branch of the United States Geological Survey, whereby it was arranged that a water power survey should be made of the Doe River. The arrangement was such that the actual work was to be prosecuted by the engineers of the U. S. Geological Survey, and the expense was to be borne equally by the State and the United States Geological Surveys. Dr. Ashley's purpose in doing this was to obtain the data of a single survey which should serve as an exhibit, so to speak, of what might have been done on a much larger scale, if the appropriation of $15,000.00 cotemplated in the bill cited in the opening paragraph of this Bulletin had been made. The share of the expense which has been borne by the State Geological Survey is $717.97.

The work was begun in December, 1911, under direction of Mr. A. H. Horton, District Engineer, U. S. Geological Survey, and is fully described in Mr. Horton's report which follows. The quality of the work is up to the high standard of excellence which those acquainted with the United States Geological Survey are accustomed to expect. Nevertheless, as Mr. Horton points out in his report, the time allotted for the work was much too short for the collection of all the data requisite to a complete and adequate knowledge of the water-power possibilities of the stream in question.

Daily observations of the run-off at two different stations have now been made for more than a year. But to render them of real value, they should be continued over a period of four or five years at least. Further than this, the study of possible power sites was of necessity far from being exhaustive. Enough was done to establish the fact that Doe River has good water power potentialities, and to show that there are many excellent power sites and a number of storage sites of moderate capacity. It was not learned what is the economic limit to the possible storage of water within the basin, nor what is the economic total amount of possible power development on the River. To accom-

plish these ends, a more elaborate survey than Dr. Ashley had in view would be required, or than could be expected for the expenditure which has been made. The results obtained amply justify the effort and the outlay they have occasioned.

The writer has thought best in reproducing Mr. Horton's report to omit the tabulations of daily gauge readings, but has not omitted his calculations of the daily run-off based on these gauge readings. He has combined the three sheets on which were plotted the map and profile of the river into a single continuous map and profile, to a much smaller scale, preferring to publish the same in this way. Since the original tracings are kept on file, persons interested in seeing the large scale drawings may do so by applying to the State Geologist.

The report of Mr. Horton follows, on page 83.

DOE RIVER REPORT

DEPARTMENT OF THE INTERIOR.
UNITED STATES GEOLOGICAL SURVEY—WATER RESOURCES BRANCH
Newport, Kentucky, Nov. 15, 1912.

DR. A. H. PURDUE, State Geologist of Tennessee,
Nashville, Tennessee.

DEAR SIR:—There is transmitted herewith my report covering the results of cooperative work between the U. S. Geological Survey and the State Geological Survey of Tennessee.

The work has been done in accordance with the regulations of the U. S. Geological Survey under the general supervision of Mr. M. O. Leighton, Chief Hydrographer. The data collected previous to 1911 were obtained under the direction of M. R. Hall. The 1911 and 1912 data were obtained under my directions assisted by T. C. McEwen and C. T. Bailey.

The gauging stations on the Doe River at Blevins and Valley Forge will be continued until January 1, 1913, at least, so as to have a complete year's record of the run-off of the Doe River at these two places. As I have pointed out in my report, accurate estimates of water power can not be made without long time records of run-off. Tennessee has a great future as a water power State. In order that its water power possibilities may become known and be developed economically the surface run-off should be determined for as long a period as is practicable. I trust that you will be able to continue and increase the stream flow work in the State during 1913.

Mr. Switzer stated to me under date of November 7, 1912, that he intended to make use of this report in his bulletin on the Water Powers of Tennessee. In making any estimates of the amount of water power available on the Doe River it should be noted that the stream flow data in the accompanying report have been obtained from records less than a year in length, and should, therefore, only be used with that fact in view.

Acknowledgments are due to Mr. McEwen and Mr. Bailey for their interest and energy in the work assigned to them, and to the U. S. Weather Bureau for rainfall records. Special acknowledgments are due to Mr. G. W. Hardin, Vice President and Superintendent of the Eastern Tennessee and Western North Carolina Railroad Company, for his courtesy in allowing trains to stop to permit the river survey party to get on and off convenient to work. I wish to thank Dr. G. H. Ashley, the former State Geologist, for his cooperation and interest, and also to thank you for your cooperation and courtesy. Yours very truly,

A. H. HORTON, *District Engineer.*

INTRODUCTION.

In November, 1911, a cooperative arrangement was made between the U. S. Geological Survey and the State Geologist of Tennessee whereby a survey and study of the Doe River in Tennessee was to be made in order to determine its value for water power

purposes. It was decided to make a profile survey of the riv from Roan Mountain to Elizabethton and to make a study of t run-off of the river. The results of the survey and investigati of the run-off were to be embodied in a report to the State Geol gist of Tennessee about November 15, 1912. The U. S. Geolog cal Survey and the State of Tennessee were each to expend a equal amount upon the work.

A river survey party was hastily organized the first part December, 1911, and started at Roan Mountain with instruction to finish the survey of the river to Elizabethton before the end o the month. Gauging stations were established at which the rive stage was read daily and measurements of the flow were made The river survey was completed about the 29th of December, 1911 The gauging stations have been maintained to date. The accom- panying report contains the results of the study of the run-off o Doe River and the results of the profile survey. The report comprises all the available run-off data of the Doe River collected by the U. S. Geological Survey and the data collected under the cooperative arrangement, and a map of the Doe River from Roan Mountain to the mouth at Elizabethton showing the general plan of the river and the river profile at low water.

Part I includes the stream flow data arranged as usually present- ed in the U. S. Geological Survey water-supply papers. The stream-flow data presented are distinctly preliminary, as there are available but few measurements with very little range in stage from which to draw rating curves. It is thought, however, that the low water flow has been determined fairly accurately. At- tention is invited to the foot-note following the tables of monthly estimates of discharge for each station.

Part II includes the plan and profile of the river from Roan Mountain to Elizabethton in three sheets, a brief discussion of the methods used in making the survey, and a general discussion of the water power possibilities with photographs of dam sites and reservoir sites.

SURFACE WATER-SUPPLY OF DOE RIVER.

DOE RIVER DRAINAGE BASIN.

PART I.

GENERAL DISCUSSION

The drainage basin of Doe River is located in the central and southern part of Carter County, Tennessee. Carter County is

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one of the border counties near the northeast corner of Tennessee. All of the basin, except about two square miles which are in North Carolina, lies in Carter County. The total area of Carter County is 345 square miles. The area of the Doe River basin is 142 square miles, or about 40 per cent. of the total area of the county.

Doe River rises in the high and mountainous area to the north and west of Roan High Knob. The main stem of the river has its source not far from Hughes Gap on the Tennessee-North Carolina boundary line. From there it flows northeasterly to Roan Mountain where it is joined by Wilson Creek, locally known as Shell Creek. From Roan Mountain it flows northwesterly and joins the Watauga at Elizabethton. The Watauga is a tributary of the South Fork of the Holston River. The total length of the river is about 29 miles. There are only two tributaries of any importance, both of which join the river near Hampton, about 7 miles above the mouth. Tiger Creek, as it is named on the topographic sheets, or Little Doe River as it is known locally, drains the western corner of the basin and joins the Doe, on the left bank, immediately above Hampton. Laurel Fork Creek flows parallel to the Doe and drains the northeastern side of the basin and joins the Doe on the right bank immediately below Hampton. Wilson Creek, which joins the Doe at Roan Mountain, is much smaller than either of the above tributaries.

The drainage area is roughly rectangular in shape with a narrow portion extending from Hampton to Elizabethton. The rectangular portion is about 15 miles long and 10 miles wide. The narrow portion from Hampton to Elizabethton is about 5 miles long and 2 miles wide. The following table gives the drainage area at different points in the basin.

TABLE 21. *Drainage areas of Doe River at different points.*

Locality (above)	Area square miles
Mouth	141
U. S. G. S. Staff gauge	139
E. T. and W. N. C. R. R. Bridge at Valley Forge gauging station	132
Below mouth of Laurel Fork Creek	129
Below mouth of Little Doe (Tiger Creek)	101
E. T. and W. N. C. R. R. Bridge at Blevins gauging station	62.2
Below mouth of Roaring Creek	55.1
Below mouth of Wilson Creek	40.7
TRIBUTARIES	
Laurel Fork Creek, area above mouth	27.0
Little Doe River (Tiger Creek) area above mouth	33.0

The sources of the river are at an elevation of about 5,000-6,000 feet. Roan Mountain Knob has an elevation of 6,313 feet. At Roan Mountain the elevation is 2,560 feet; at Blevins, at the head of the upper canyon, the elevation is 2,270, at the lower end of the canyon the elevation is 1,850, a fall of 420 feet through the canyon in a distance of a little over 4 miles. At Hampton the elevation is 1,770 feet and at the mouth of the river at Elizabethton the elevation is 1,503 feet. The following table gives the elevations and distances along the river as determined by a profile survey made in December, 1911.

TABLE 22. *Distances and elevations along Doe River from mouth to Wilson Creek.*

Locality	Miles above mouth	Elevation	Fall bet'n points in feet.
Mouth (Watauga River)	0	1,503	
Covered Bridge, Elizabethton, U.S.G.S. Reference gauge on bridge	0.6	1,522	19
U. S. G. S. Gauge on right bank	1.2	1,535	13
Foot of dam	1.7	1,548	13
Top of dam	1.7	1,553	5
	2.5	1,568	15
Laurel Fork R. R. Co.'s bridge	3.6	1,599	31
E. T. and W. N. C. R. R. bridge, Valley Forge, U. S. G. S. gauging station	3.9	1,612	13
	5.0	1,644	32
E. T. and W. N. C. R. R. bridge	5.8	1,686	42
Laurel Fork Creek	6.9	1,745	59
Highway bridge at Hampton	7.3	1,767	22
Little Doe River or Tiger Creek	7.9	1,793	26
	8.7	1,836	43
	10.0	1,933	97
Pardee Point	10.4	1,996	63
	11.0	2,062	66
E. T. and W. N. C. R. R. bridge	11.8	2,154	92
E. T. and W. N. C. R. R. bridge	12.0	2,178	24
	13.0	2,249	71
E. T. and W. N. C. R. R. Bridge, Blevins, U. S. G. S. gauging station	13.4	2,268	19
Blevins R. R. station	13.7	2,280	12
Hopson Post-office	15.2	2,327	47
White Rock R. R. station	15.7	2,350	23
	16.6	2,408	58
Roaring Creek	17.3	2,447	39
	18.0	2,468	21
George's Creek	18.5	2,501	33
	19.0	2,508	7
	20.0	2,536	28
Roan Mountain	20.9	2,559	23
Wilson Creek, or Shell Creek	21.2	2,572	13

Probably three-quarters or more of the area that may be considered as being located at the sources of the main stream and more

important tributaries is forested. The land along the river bottoms is, in general, cleared. Lumbering is being carried on extensively and will soon result in the removal of all the best timber and will reduce the forested area materially.

The rainfall varies from 45 inches at Elizabethton to 60 inches or more at the highest parts of the basin. The reader is referred to the tables of rainfall, following the stream flow data, for Elizabethton and for other points about the same elevation of the source of the river. These records show that the rainfall is much greater at the elevated sources of Doe River than it is at the mouth of the river at Elizabethton.

Like most of the streams in eastern Tennessee the basin of Doe River abounds in springs, some of which are of considerable size, The flow of Fish Spring near Elizabethton was found to be about 7½ cu. ft. per second. Willow Spring, about 3½ miles above the mouth of the river, has a discharge of about 1.7 cu. ft. per second. The spring at Hampton is said to have a discharge of about 11 cu. ft. per second. According to those who live near, the flow never varies summer or winter and remains at a constant temperature. Fish Spring gets slightly discolored after heavy rains but the other two remain clear and sparkling the year round. Elizabethton obtains its water supply from the spring at Hampton. The owners of the Hampton spring state that the water is soft and practically absolutely pure. The numerous springs in the drainage basin tend to keep the flow of the river constant during long continued droughts.

In general, winter conditions are mild and ice forms only during severe winters. The Eastern Tennessee and Western North Carolina Railroad parallels the river from Valley Forge to Roan Mountain. Its grade line is from 10 to 100 feet above the river.

The following gauging stations have been maintained in this basin:

Doe River at Blevins, Tenn., 1911-1912;
Doe River at Valley Forge, Tenn., 1911-1912;
Doe River at Elizabethton, Tenn., 1907-1908, 1912.
The results of the gaugings are as follows:

Doe River at Blevins, Tenn.

Location: At Eastern Tennessee and Western North Carolina Railroad bridge, one-fourth mile north of Blevins, Tenn.
Records available: Dec. 16, 1911 to Oct. 31, 1912.
Drainage area: 62.2 square miles.

Gauge: Standard chain gauge attached to upstream guardrail of covered wooden through bridge.

Channel: Bottom sandy; may shift. Point of control probably permanent.

Discharge measurements: Made from upstream side of bridge, or by wading at section ¼ mile above bridge.

Winter flow: The relation of gauge height to discharge may be occasionally affected by ice, but only for short periods during unusually severe winters.

Accuracy: The gauge readings are reliable and accurate. See foot-note following tables of monthly estimates in regard to accuracy of the estimates of run-off.

Regulation: None.

TABLE 23. *Discharge measurements of Doe River at Blevins Tenn., 1911-1912.*

Date	Hydrographer		Width feet	Area of Section sq. feet	Mean velocity ft. per sec.	Gauge height in ft.	Discharge cu. ft. per sec.
Dec 9, 1911	Horton & Bailey	1	28	a. 23.7	1.35	1.74	31.9
Dec. 23, 1911	A. H. Horton	2	60	115	1.27	2.19	146.0
Sept. 11, 1912	A. H. Horton	3	24.8	b. 22.5	1.10	1.69	24.8

a. Not at regular section. b. At wading section.

TABLE 24. *Discharge in second feet of Doe River at Blevins, Tennessee, for 1911-1912.*

Day	Dec. 1911	Jan. 1912	Feb.	Mch.	Apr.	May	June	July	Aug.	Sept.	Oct.
1	------	118	134	140	252	252	72	61	63	29	33
2	------	101	98	130	481	186	68	52	58	29	29
3	------	96	107	110	311	198	121	58	68	31	29
4	------	85	112	104	226	164	82	164	68	28	28
5	------	52	90	101	175	164	78	164	52	28	26
6	------	118	118	107	154	157	88	107	52	17	26
7	------	150	118	107	157	168	82	70	47	31	26
8	------	131	112	121	128	157	63	172	43	47	26
9	------	121	80	194	110	124	56	137	45	31	26
10	------	107	85	157	110	118	58	101	56	29	25
11	------	101	107	131	101	107	50	154	47	26	26
12	------	95	110	194	93	101	50	115	33	26	24
13	------	90	128	206	93	82	45	90	38	61	26
14	------	56	70	194	82	85	68	101	40	33	45
15	------	66	77	924	85	210	150	63	40	33	43
16	85	76	70	440	80	110	101	58	40	33	26
17	47	96	70	222	90	128	68	52	40	29	26
18	40	126	75	182	93	98	118	63	36	43	26
19	40	157	75	161	96	93	75	445	61	45	38
20	38	137	77	154	85	88	61	222	56	28	29
21	65	112	226	140	75	82	47	175	70	26	22
22	121	107	206	121	202	78	50	164	80	26	26
23	144	104	157	110	150	72	61	137	61	154	33
24	144	56	179	206	124	68	54	110	40	75	33
25	147	56	144	168	107	107	56	248	40	54	26
26	144	61	330	140	98	68	52	121	40	54	26
27	157	61	326	134	194	65	50	110	40	63	25
28	118	52	157	161	172	78	50	85	33	47	24
29	112	179	150	630	321	179	50	82	29	43	26
30	90	194	------	359	652	104	56	82	40	40	24
31	150	150	------	230	------	86	------	65	36	------	26

NOTE.—See footnote following tables of monthly estimates.
NOTE.—Gauge heights Jan. 11-12 top ice.
Discharge Jan. 11-12, 15-18 estimated.
Discharge Mar. 1-3, interpolated.

TABLE 25. *Monthly discharge of Doe River at Blevins, Tenn., or 1911-1912.*

Drainage Area, 62.2 square miles.

	Discharge in cu. ft. per second				Run-off.	
	Max	Min.	Mean	Per sq. mile	Depth in inches on drainage area	Total in acre-ft.
Dec. 16-31, 1911	157	38	103	1.66	0.99	3,270
January, 1912	194	52	102	1.64	1.89	6,270
February	330	70	131	2.11	2.28	7,540
March	924	101	209	3.36	3.87	12,900
April	652	75	170	2.73	3.05	10,100
May	252	65	122	1.96	2.26	7,500
June	150	45	69.3	1.11	1.24	4,120
July	445	52	123	1.98	2.28	7,560
August	80	29	48.1	.774	.89	2,960
September	154	17	41.3	.664	.74	2,460
October	45	22	27.9	.449	.52	1,720
November						
The period Jan. 1. to Oct. 31	924	17	104	1.67	19.02	63,130

NOTE.—Monthly estimates for 1911 and 1912 are based upon daily discharges obtained from a rating table based upon 3 discharge measurements made during 1911-1912 and a field determination of the point of zero flow. The rating table is fairly well defined below gauge height 2.5 feet (discharge 270); above this point the table is only an approximation and may be considerably in error.

DOE RIVER AT VALLEY FORGE, TENN.

Location: At Eastern Tennessee and Western North Carolina Railroad bridge at Valley Forge, about 4 miles above mouth of river.

Records available: Dec. 11, 1911, to Oct. 31, 1912.

Drainage area: 132 square miles.

Gauge: Standard chain gauge attached to bridge.

Channel: Bottom sandy, may shift. The current is at a pronounced angle to the bridge. Point of control probably permanent.

Discharge measurements: Made from up-stream side of bridge or by wading at section 50 feet above bridge.

Winter flow: Ice may affect the relation of gauge height to discharge for short periods, but only during unusually severe winters.

Accuracy: The gauge readings are considered reliable and accurate. See footnote following tables of monthly estimates in regard to accuracy of the estimates of run-off.

Regulation: None.

TABLE 26. *Discharge measurements of Doe River at Valley Forge, Tenn., 1911-1912.*

Date	Hydrographer		Width ft.	Area of Section sq. ft.	Mean velocity ft. per sec.	Gauge height in ft.	Discharge cu. ft. per sec.
Dec. 9, 1911	Horton & Bailey	1	87	a. 115	0.62	1.17	71.6
Dec. 23	A. H. Horton	2	105	201	1.38	1.81	278
Sept. 7, 1912	A. H. Horton	3	85	b. 126	0.65	1.24	81.7

a. Not at regular section. b. Wading section.

TABLE 27. *Discharge in second feet of Doe River at Valley Forge, Tenn., for 1911-1912.*

Day	1911 Dec.	1912 Jan.	Feb.	Mch.	Apr.	May	June	July	Aug.	Sept.	Oct.
1	.....	219	227	242	461	576	208	171	134	79	88
2	.....	177	197	204	1,280	445	201	164	126	73	83
3	.....	177	120	194	753	496	293	164	149	73	75
4	.....	158	158	190	519	419	208	197	152	73	75
5	.....	71	123	230	394	383	174	339	126	107	71
6	.....	81	140	242	325	368	201	242	115	81	71
7	.....	134	107	263	373	368	187	164	107	107	67
8	.....	140	129	298	267	344	158	155	105	107	63
9	.....	161	115	513	250	306	143	219	105	93	63
10	.....	120	123	430	234	263	137	212	123	71	63
11	75	123	115	363	216	246	120	223	107	65	63
12	73	112	115	363	204	242	115	234	97	63	60
13	73	107	115	404	197	208	115	190	85	81	63
14	73	95	107	404	190	190	149	197	77	79	93
15	79	107	134	1 770	184	212	490	155	85	75	102
16	129	47	134	1,230	184	368	344	140	85	65	73
17	129	88	143	793	223	284	223	134	88	71	67
18	102	110	158	430	187	246	246	134	93	73	65
19	79	197	140	344	180	216	208	664	112	118	83
20	79	107	158	325	167	208	171	440	112	75	78
21	107	112	358	284	167	190	161	330	197	63	65
22	129	97	409	254	445	174	137	363	216	65	67
23	258	105	129	242	440	171	149	306	131	197	83
24	234	102	246	388	320	146	174	242	88	149	78
25	212	107	275	368	275	212	155	349	88	107	63
26	258	112	368	320	238	152	140	267	95	102	63
27	344	112	435	298	445	161	161	227	88	149	61
28	258	107	349	284	419	316	123	194	81	107	63
29	180	216	890	1,440	679	340	112	174	79	107	63
30	190	419	.....	785	924	363	164	164	102	95	63
31	238	267	.....	478	.....	259	.....	161	95	.....	63

NOTE.—See footnote following tables of monthly estimate.

TABLE 28. *Monthly discharge of Doe River at Valley Forge, Tenn., for 1911-1912.*

Drainage Area, 132 square miles.

	Discharge in cu. ft. per second				Run-off	
	Max.	Min.	Mean	Per sq. mile	Depth in inches on drainage area	Total in acre-ft.
December 11-31, 1911	344	73	157	1.19	0.93	6,540
January	419	47	138	1.05	1.21	8,480
February	890	107	214	1.62	1.75	12,300
March	1,770	190	464	3.52	4.06	28,500
April	1,280	167	371	2.81	3.14	22,100
May	576	146	286	2.17	2.50	17,600
June	490	112	186	1.41	1.57	11,100
July	664	134	234	1.77	2.04	14,400
August	216	77	111	.840	.97	6,820
September	197	63	92.3	.699	.78	5,490
October	102	60	70.9	.537	.62	4,360
The period Jan. 1 to Oct. 31	1,770	47	217	1.64	18.64	131,150

NOTE.—Monthly estimates for 1911 and 1912 are based upon daily discharges obtained from a rating table based upon 3 discharge measurements made during 1911-1912 and a field determination of the point of zero flow. The rating table is fairly well defined below 2.5 feet (discharge 664); above this point the table is only an approximation and may be considerably in error.

DOE RIVER AT ELIZABETHTON, TENN.

Location: About one mile above mouth of river.

Records available: June 15, 1907, to June 30, 1908. Sept. 8 to Oct. 31, 1912.

GORGE BELOW MOUTH OF ROARING CREEK. A FAIR DAM SITE.

Drainage area: 139 square miles.

Gauge: Staff gauge attached to tree on right bank.

Channel: Gravel, probably permanent.

Discharge measurements: Made from covered highway bridge about one-half mile below gauge.

Winter flow: Ice may affect relation of gauge height to discharge for short periods, but only during unusually severe winters.

Accuracy: Gauge readings are considered reliable and accurate. See footnote following tables of monthly estimates in regard to the accuracy of the estimates of run-off.

Regulation: The operation of a small power plant above the gauge may affect the normal flow of the stream to some extent.

TABLE 29. *Discharge measurements of Doe River, Elizabethton, Tenn., 1904 and 1907.*

Date	Hydrographer	Width feet	Area of section sq. feet	Mean velocity ft. per sec.	Gauge height feet	Discharge cu. ft. per sec.
May 22, 1904	B. S. Drane	128	253	1.21	a1.55	307
July 11	J. M. Giles	129	166	0.60	0.79	99
Oct. 20	B. S. Drane	134	131	0.37	0.64	48
June 17, 1907	W. E. Hall	129	285	1.41	b1.50	403
Aug. 9	W. E. Hall	127	283	1.78	1.60	504
Sept. 5	B. M. Hall, Jr.	125	243	1.42	1.48	357
Sept. 5	B. M. Hall, Jr.	125	242	1.38	1.43	334

a. Reference gauge at bridge. b. Staff gauge 2,600 ft. above bridge.

TABLE 30. *Discharge in second feet of Doe River at Elizabethton, Tenn., for the year 1907-1908.*

Day	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mch.	Apr.	May	June
1	134	134	124	156	92	124	618	359	903	960	257	183
2	200	134	115	156	98	106	562	216	562	1590	960	183
3	156	115	115	134	106	106	257	200	454	618	216	170
4	134	115	675	134	106	115	183	183	403	403	183	403
5	134	115	562	115	98	134	903	183	732	257	216	236
6	134	134	183	115	85	156	960	257	903	257	183	216
7	134	134	156	115	76	216	732	183	618	216	618	183
8	115	156	960	134	85	236	359	183	403	216	359	183
9	115	359	315	124	106	145	236	183	359	216	286	156
10	115	156	170	115	286	960	183	183	216	183	257	156
11	115	156	156	115	236	675	257	216	216	183	216	124
12	732	156	156	115	145	124	3030	286	789	183	183	115
13	505	134	145	115	119	145	1940	562	454	183	183	115
14	257	115	134	115	106	359	1540	618	454	183	156	236
15	183	98	134	106	92	115	505	2,110	359	156	156	789
16	156	106	115	98	85	145	403	960	315	505	156	454
17	675	170	115	98	92	200	315	454	216	403	156	257
18	200	134	106	115	95	257	286	216	236	286	236	183
19	183	134	98	115	85	156	236	216	216	216	732	156
20	145	98	98	115	98	124	156	170	236	216	960	156
21	134	106	156	134	92	156	156	156	403	200	505	257
22	115	1,300	257	115	74	286	156	156	403	183	236	505
23	115	1,360	2,800	115	74	359	216	156	618	183	116	359
24	115	903	846	115	257	618	183	183	1020	183	183	315
25	134	200	403	115	315	789	156	183	673	1710	183	403
26	115	156	200	115	236	359	156	183	505	960	183	359
27	134	156	183	115	200	216	183	183	286	562	183	315
28	115	156	156	124	134	454	183	183	257	359	216	216
29	562	156	156	106	106	675	183	216	257	315	216	183
30	216	145	134	98	92	200	156	------	216	286	216	156
31	145	134	----	92	------	505	156	------	216	------	200	------

NOTE.—See footnote following tables of monthly estimates.

TABLE 31. *Discharge in second feet of Doe River at Elizabethton, Tenn., 1912.*

Day	Sept.	Oct.
1		88
2		84
3		83
4		77
5		78
6		81
7		80
8	98	75
9	93	74
10	84	75
11	75	78
12	81	76
13	80	74
14	86	84
15	80	108
16	85	84
17	82	81
18	86	80
19	128	83
20	86	88
21	78	77
22	77	76
23	101	86
24	115	86
25	101	82
26	93	77
27	123	76
28	100	74
29	94	75
30	89	75
31		77

NOTE.—See footnote following tables of monthly estimates.

PLATE IX.

DAM SITE BELOW HOPSON POST OFFICE, 14½ MILES ABOVE THE MOUTH OF DOE RIVER.

TABLE 32. *Monthly discharge of Doe River at Elizabethton, Tenn., for the years 1907, 1908 and 1912.*

Drainage Area, 139 square miles.

	Discharge in cu. ft. per second				Run-off.	
	Max.	Min.	Mean	Per sq. mile	Depth in inches on drainage area	Total in acre-ft.
June 15-31, 1907	960	152	326	2.35	1.40	10,300
July	732	115	211	1.52	1.75	13,000
August	1,360	98	246	1.77	2.04	15,100
September	2,800	98	331	2.38	2.66	19,700
October	156	92	118	0.849	0.98	7,260
November	315	74	129	0.928	1.04	7,680
December	960	106	297	2.14	2.47	18,300
The period June 15 to Dec. 31	2,800	74	230	2.30	1.65	91,340
January, 1908	3,030	156	502	3.61	4.16	30,900
February	2,110	156	329	2.37	2.56	18,900
March	1,020	216	448	3.22	3.71	27,500
April	1,710	156	412	2.96	3.30	24,500
May	960	156	296	2.13	2.46	18,200
June	788	115	251	1.85	2.06	15,300
The period Jan. 1 to June 30th	3,030	115	375	2.70	18.25	135,300
September 8-30, 1912	128	75	92.0	.662	0.57	4,200
October	108	74	80.4	.578	0.67	4,940

NOTE.—Monthly estimates for 1907, 1908 and 1912 are based on daily discharges obtained from a rating table based on 4 discharge measurements made during 1907, a field determination of the point of zero flow in September, 1912, upon discharge measurements made at Valley Forge and transferred to Elizabethton by proportional areas, and by measuring the inflow from springs between the two stations, and upon the assumption that there has been no change in the relationship between gauge height and discharge since June, 1907, to November 1912, which is not improbable. The rating table is fairly well defined below gauge height 2.0 feet (discharge 960); above this point the table is an approximation only and may be considerably in error.

TABLE 33. *List of miscellaneous discharge measurements made in Doe River drainage basin during the year 1900.*

No.	Date	Stream	Locality	Gauge Height feet	Discharge cu. ft. per sec.
1	Aug. 3, 1900	Laurel Fork Cr.	Hampton, Tenn.	4.81	30.0
2	Aug. 17	"	"	4.50	15.0
3	Oct. 5	"	"	4.33	9.0
4	Dec. 29	"	"	4.95	27.0
1	Aug. 3	Little Doe River	"	5.58	35.0
2	Oct. 5	"	"	5.22	17.0
3	Dec. 29	"	"	5.70	28.3
1	Aug. 3	Doe River	Two miles below Roan Mountain, Tenn., near Hampton	1.54	41.3
1	Aug. 3	"	"	4.44	72.0
2	Aug. 18	"	Tenn.	4.19	50.0
3	Oct. 5	"	"	4.15	39.3
1	Aug. 2	"	Above Elizabethton, Tenn.	4.06	143.0
2	Aug. 17	"	"	3.80	106.0
3	Oct. 5	"	"	3.77	82.0
4	Dec. 31	"	"	4.77	304.0

TABLE 34. *Mean monthly precipitation.*

Elizabethton, Carter County, Tennessee. Elevation 1,575 ft.

	Jan.	Feb.	Mch.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1869	4.80	2.70	2.95	3.25	6.80	5.90	3.90	3.89	2.25	3.70	2.72	3.60	46.46
1870	2.65	3.22	3.40	4.90	4.45	14.17	2.71	4.09	2.10	3.17	1.45	2.15	48.46
1871	1.70	2.85	4.25	5.91	------	4.25	3.19	2.65	1.02	2.31	3.35	0.95	------
1872	1.96	1.42	2.75	5.63	5.63	16.38	1.10	5.17	2.55	2.36	0.88	9.87	55.70
1873	3.83	5.54	3.33	1.68	4.83	------	------	------	------	------	------	------	------
1895	------	------	------	2.37	3.92	3.32	9.54	2.89	0.64	1.88	1.99	1.95	------
1896	0.46	2.61	4.42	3.09	3.34	7.87	10.56	0.89	4.31	1.27	4.67	1.56	45.05
1897	2.31	6.63	8.06	2.84	4.34	5.60	6.62	3.06	2.71	1.19	1.72	3.23	48.31
1898	5.13	1.04	5.09	4.35	3.89	5.66	4.44	3.98	4.27	3.16	2.22	1.23	44.46
1899	3.13	6.07	10.72	2.08	4.86	2.75	3.58	3.03	3.07	1.23	1.88	2.54	44.94
1900	2.23	3.70	3.98	1.14	1.16	4.41	3.94	4.40	3.05	2.55	3.81	3.31	37.68
1901	3.81	1.19	3.26	5.27	7.36	8.34	1.66	12.14	1.36	2.05	0.85	6.74	54.03
1902	2.85	4.76	3.55	2.05	1.87	8.19	4.40	3.06	5.43	2.03	2.99	1.57	42.75
1903	1.71	6.19	4.77	4.63	3.30	2.45	4.02	4.48	0.30	1.68	3.37	1.56	38.46
1904	2.06	3.28	6.07	2.64	3.71	3.68	2.05	4.75	1.26	0.02	2.13	4.72	36.37
1905	2.91	3.73	2.30	3.39	4.27	2.42	4.46	4.73	1.85	2.54	1.05	3.12	36.77
1906	3.93	0.48	2.46	1.22	3.43	6.22	4.80	8.12	3.42	1.46	1.83	3.66	41.03
1907	------	------	------	------	------	------	------	------	------	------	------	------	------
1908	4.39	2.80	4.49	5.46	5.60	4.33	7.42	4.07	1.32	2.92	2.11	4.38	49.29
1909	2.21	3.18	4.03	2.62	3.62	6.51	2.63	2.80	3.90	2.66	0.95	1.48	36.59
1910	------	2.07	1.41	2.98	3.10	5.13	7.87	3.34	5.88	1.52	1.40	3.40	------
1911	3.57	4.07	4.55	3.64	1.22	3.50	1.79	2.65	2.26	4.83	1.87	2.05	36.00
1912	3.89	2.39	4.60	6.05	3.95	3.80	6.83	3.23	3.28	1.78	------	------	------
Total.	59.53	69.92	90.44	77.19	84.65	124.88	97.51	87.42	56.23	46.31	43.24	63.07	------
Mean.	2.98	3.33	4.31	3.51	4.03	5.95	4.64	4.16	2.68	2.21	2.16	3.15	43.11

Linville, Mitchell County, N. C. Elevation 3,800 ft.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1891	------	------	------	------	------	------	------	------	------	1.10	10.79	7.37	------
1892	1.89	1.29	2.01	3.75	4.82	------	------	------	------	------	------	------	------
1895	6.62	2.30	6.05	9.60	7.79	3.49	5.24	6.89	2.55	1.21	2.53	8.94	63.21
1896	3.82	5.66	3.58	4.80	2.67	4.62	11.24	1.58	9.38	1.58	6.74	1.62	57.29
1897	3.98	10.23	6.92	5.12	4.54	6.75	7.38	2.81	1.83	3.57	2.24	4.47	59.95
1898	4.38	0.90	3.71	3.03	2.65	4.58	9.29	8.48	9.59	18.49	2.54	3.41	71.05
1899	3.38	7.13	11.89	2.45	2.92	3.21	3.39	5.60	4.41	2.00	1.50	7.42	55.30
1900	2.63	5.34	7.60	5.51	2.17	7.07	3.99	3.70	4.42	13.40	4.47	3.95	64.25
1901	2.97	3.15	------	------	------	------	------	------	5.82	2.07	0.52	13.66	------
1902	1.71	8.90	3.92	2.33	4.18	7.49	3.67	2.95	7.09	3.90	3.64	3.93	53.71
1903	3.16	8.45	9.55	------	1.82	5.51	4.55	4.15	4.97	------	3.83	2.50	------
1904	3.30	2.97	7.04	3.11	9.85	4.47	4.69	5.63	2.23	------	3.40	3.46	50.15
1905	4.06	6.05	2.25	3.44	7.06	7.74	11.21	9.70	------	3.66	------	------	------
1906	------	1.46	4.15	3.61	2.76	6.80	11.31	------	16.02	9.28	------	------	------
Means.	3.49	4.91	5.72	4.25	4.44	5.61	6.91	5.15	5.69	5.02	3.52	5.52	60.23

Banners Elk, Avery County, North Carolina. Elevation 3,750 ft.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1907	------	------	------	------	------	------	------	------	5.32	1.90	2.84	5.81	------
1908	8.65	4.86	5.11	6.64	5.57	5.67	7.60	8.24	1.30	12.54	1.23	5.54	72.95
1909	3.36	5.38	6.58	4.14	8.68	5.84	4.18	5.44	3.94	4.00	0.58	4.31	56.43
1910	4.80	3.88	0.62	3.12	4.29	6.81	5.75	8.87	4.78	2.91	1.39	4.40	51.62
1911	3.73	2.64	5.70	5.38	2.05	3.40	2.59	6.95	2.40	4.25	3.66	4.19	46.94
1912	2.65	4.88	6.74	5.18	3.85	4.35	6.89	1.58	3.85	1.08	------	------	------
Means.	4.64	4.33	4.95	4.89	4.89	5.21	5.40	6.22	3.60	4.45	1.94	4.85	55.37

PLATE X.

RESERVOIR SITE BELOW HOPSON POST OFFICE, 15 MILES ABOVE THE MOUTH OF DOE RIVER.

Blowing Rock, Watauga County, North Carolina. Elevation 4,090 ft.

	Jan.	Feb.	Mch.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1893	------	4.44	2.73	5.42	3.57	10.73	5.08	7.67	10.29	------	2.21	1.86	------
1894	------	5.18	1.19	0.81	3.33	2.30	4.74	2.63	3.73	3.96	1.22	5.25	------
1895	6.22	2.10	------	4.54	1.82	0.94	0.58	5.88	1.41	------	------	------	------
1911	------	------	------	------	------	------	4.55	------	------	4.08	------	5.10	------
1912	------	------	------	3.52	5.87	6.09	11.38	2.71	8.61	1.95	------	------	------
Means	6.22	3.91	1.96	3.57	3.65	5.02	5.27	4.72	6.01	3.33	1.72	4.07	49.45

PART II

Method of Work

The survey of Doe River was made by the transit and stadia method. Elevations were carried by means of vertical angles and by using the transit as a level whenever possible. Distances were obtained by sighting at stadia rods and by reading the interval subtended by the stadia wires in the transit; this interval multiplied by the proper coefficient gave the distance from the transit to the rod. Azimuth was carried from the starting point by back sighting at the next to the last transit station when set up at the last station. Azimuth was obtained from observations on the sun.

The water surface, banks of the river, roads, and railroads were located by stadia sights, and the river and adjacent topography were sketched in a sketch book as the survey progressed. The plan and profile of the river and the Eastern Tennessee and Western North Carolina Railroad, which paralleled the river most of the way, were located as accurately as could be done by the stadia method of surveying. In general, the topography adjacent to the river up to the elevation of the grade of the railroad was sketched in with the aid of a few stadia shots.

The method of using the transit as a level and accompanying every other set-up was tried, azimuth being obtained by needle bearings on backsights and foresights. But the slope was so steep that only very short sights could be made with the telescope level, and as it was found most economical and convenient to run the transit line on the railroad right of way, and because local attraction from the rails affected the needle, the method was not used.

There were four men in the party, a recorder, who was chief of party, a transitman, and two rodmen. The survey was started December 13th and finished December 27th, or in about 13 work-

ing days. The total length of the river surveyed was 21 miles or about 1.6 miles per day, which is fair progress considering the short days and the generally inclement weather during December. The cost per mile for the field work was about $12.00, which compares favorably with the cost of work in other parts of the country. The above cost only includes the expenditures of the surveying party from December 13th to December 27th. Nearly a week was spent in reconnaissance, establishing gauges, making discharge measurements, and in organizing and equipping the field party. Fortunately the train schedule at Roan Mountain permitted the use of trains in going to and from field work.

River profile work can probably be done in Tennessee for from $10 to $15 per mile. The work can best be done in late summer and fall when the foliage is dropping, streams are at a uniform stage, and weather conditions are favorable.

The results of the survey are shown on the three sheets accompanying this report.* The plan and profile of the river from the mouth of Wilson Creek to the mouth of the river at Elizabethton are shown. The plan and profile are divided into sections so as to make economical use of the space on a sheet. The plan and the profile belonging to the plan are on the same sheet.

The scale of the plan is 500 feet to the inch or 1 in 6,000. The horizontal scale of the profile is the same and the vertical scale is 1 inch—10 feet. These sheets were drawn with the expectation that they would be reduced one-half for publication and the scale has been expressed on the sheets as 1 to 12,000 so as to read correct when reduced one-half.

Water Power.

The drainage basin of the Doe River is a mountainous area, covered to a great extent with forests except along stream bottoms, which are, in general, cleared. Above Roan Mountain the slope of the main stream and tributaries is precipitous, as the fall from the sources to Roan Mountain is approximately 3,500 feet in a distance of 8 miles. In this section there are many opportunities for small water powers. From Roan Mountain to Blevins the fall is much smaller, averaging about 40 feet to the mile. Through this section the valley is comparatively narrow with now and then a gorge. At places the valley is perhaps a quarter of a mile wide.

*Combined and reduced for publication in this Bulletin into a single sheet.—J. A. Switzer.

PLATE XI.

RESERVOIR SITE AT BLEVINS.

Plates VIII to XII are typical views of the section from Roan Mountain to Blevins. In this section low dams could be built almost anywhere. Just below Roaring Creek a dam of considerable height could be built (See Plate VIII). A dam at this place would not interfere with the railroad as the railroad cuts across a bend in the river. Plate IX is a photograph of another possible dam site, with the reservoir site above it shown on Plate X. A dam 40 or 50 feet high might be built at this point. The railroad, however, would have to be raised, but this would not be expensive through this section, as the grade is nearly level above the dam site. Plate XI shows a reservoir site that could be utilized by a dam at the head of the canyon just below Blevins. A dam 30 feet high just above the railroad bridge would give a storage capacity of approximately 31,000,000 cubic feet. A higher dam would give a much larger storage capacity but would necessitate raising the railroad tracks. Plate XII is a photograph of a fair dam site. A dam 50 feet high could probably be built here which would back water up into the storage basin shown in Plate XI. The railroad would have to be raised, however.

From the head of the canyon below Blevins to the lower end of the canyon the fall averages over 100 feet to the mile. Through this section the river is confined in a narrow canyon whose sides rise hundreds of feet above the river. In this stretch of the river there are numerous dam sites, the height of which are only limited by the grade line of the railroad. Probably the construction of a dam of the maximum height, with a pipe line from it running down the river to a suitable location for a power plant, would be the best solution, as considerable storage could be obtained by taking the pipe line out below the top of the dam and a large increase in head could be obtained, depending upon how long a pipe line was built.

Below this section of the river there is a rather broad valley with a steep slope in which the Little Doe and the Laurel Fork join the Doe. Hampton, a town of perhaps 500 people, is located on the Doe River in this valley. The head of the lower canyon is a short distance below Hampton. The average fall through this valley to the head of the lower canyon is about 50 feet per mile. Low dams with canals to develop additional head could be built through this section. The steepest part of the lower canyon extends from about mile 6.5 to mile 5.5. (See Pl. VII.) The fall in this mile is about 60 feet.

The sides of the canyon are not so steep nor so high as in the upper canyon. From about mile 4 to the mouththe river flows through a comparatively open country, the land on the west side of the river being cleared and cultivated and is comparatively level. The land on the east side is more rolling and not so suitable for cultivation. Through this section the fallof the river averages about 25 feet to the mile. Low dams with flumes or canals could be built along this stretch.

From an examination of the profile and from the above description it is evident that there are excellent possibilities for water power development on Doe River, provided the run-off is sufficient. Estimates of the amount of water power are dependent upon less than a year's record of the run-off, a period much too short upon which to base accurate estimates. If there were records at Valley Forge and at Blevins extending over a period of at least 5 years, fairly accurate estimates could be made of the amount of water power available at any point in the upper canyon and in the lower canyon, the sections of the river where the largest developments are possible. The records that are available show that the minimum flow at Blevins is 17 cu. ft. per second, with a mean for the month of October of about 28 cu. ft. per second. Assuming that by means of storage a flow of 28 cu. ft. per second could be furnished, it would be possible to secure 2½ horse power per foot of fall with turbines of 80 per cent efficiency. With heads of 50 feet and 100 feet this would give 125 and 250 horse power, respectively.

At Valley Forge, the data show that the minimum flow during the period covered by the records was 60 cu. ft. per second, not considering the minimum for January of 47 cu. ft. per second which was undoubtedly caused by the abnormally cold weather, with a mean for the month of October of 71 cu. ft. per second. Considering that this flow, 71 cu. ft. per second, could by means of storage be used as the minimum, it would be possible to secure 6½ horse power per foot of fall with turbines of 80 per cent. efficiency. With heads 50 feet and 100 feet this would produce 325 and 650 horse power, respectively. The above estimates are based on less than a year's record and should under no condition be used for construction of a power plant, as another year's record might give values 50 per cent or more less than those obtained in 1911-1912.

DAM SITE BELOW THE RAILROAD BRIDGE AT BLEVINS.

An examination of the rainfall records accompanying this report would indicate to some extent whether the 1911-1912 run-off data represented the flow for an average year, a dry year, or for a wet one. A long time record of the flow of this stream would determine beyond a reasonable doubt the amount of water available for any power development.

Material for the construction of dams is abundant and easily accessible. Rock foundations are available practically everywhere. The Eastern Tennessee and Western North Carolina Railroad, a narrow gauge railroad paralleling the river, would furnish convenient transportation facilities for machinery and construction material.

Doe River has been subject to one or two very severe floods The flood of May, 1901, resulted from a long continued rain over the entire basin with a cloudburst at the headwaters. The flood did a large amount of damage. Cultivated fields along the river were washed away or covered with rocks and gravel. Bridges, trees, and buildings were carried away. Traffic on the railroad was suspended for weeks. Persons living in the mounains stated that the mountain sides were covered with slides. Eye-witnesses of these slides stated that trees, rocks, boulders, mud and water would suddenly spout into the air and go rolling down the mountain into the streams. Those living along the river stated the river was full of mud, rocks, trees, stumps, and trash of all description, which, by forming dams, caused the river to be much higher than it would have been otherwise. At Roan Mountain the water was a little over the railroad tracks. At the Blevins bridge the water was about 5 feet below the bottom of the bridge; this would make the water by the present gauge about 24 feet. At Hampton the water was about one foot over the railroad. As near as could be determined the stage on the staff gauge at Elizabethton would have been approximately 15 feet. This may be as much as 5 feet in error. A large amount of damage was done in that part of Elizabethton situated on the east side of the river. It is claimed by those living along the river that there was as much water in the flood of February, 1902, as in May, 1901, but it did not get as high because the river was free from drift and debris.

A. H. HORTON,
District Engineer, U. S. G. S., Nov. 13, 1912.

APPENDIX A.

DIGEST OF PROCEDURES AND LAWS OF OTHER STATES WITH REFERENCE TO WATER POWER.

Before citing the laws of the various States and countries, couched as some of them are in legal terminology difficult to comprehend, it may serve a useful purpose if we summarize in non-technical language the salient features of these laws. The Survey is not informed upon the laws of all the States, but enough citations follow to point pretty conclusively to the trend of legislative action with respect to the water power resources of the world. We shall confine our attention to the States of Maine, New York, New Jersey, Pennsylvania, California, Idaho, Wisconsin, and Oregon, and the countries of Canada, France, Italy and Switzerland.

NEW YORK.

In the body of the Bulletin, extended reference has been made to the steps which New York has taken in the direction of establishing complete State control of the water power resources of that State. Nevertheless a complete and succinct statement of the experience of the State will serve the purpose of a greater degree of completeness in the Appendix than if it were passed over.

The following digest is taken from a publication by the New York State Water Supply Commission.

> "Following the recommendation made by Governor Hughes in his annual message of 1907, the Legislature passed a bill, which became a law and is known as the "Fuller Act,"
>
> "This law committed the State, for the first time, to a definite policy regarding the conservation and development of water powers. It 'authorized and directed' the State Water Supply Commission to devise plans for the progressive development of the water powers of the State under State ownership, control and maintenance for the public use and benefit and for the increase of public revenue. When it is remembered that the State, before the enactment of this law, had been giving away water power franchises in perpetuity to all applicants with persistence or influence enough to obtain them, it will be seen that the Fuller Act was a long step in advance.

"It directed the commission to investigate all the water powers in the State and to report upon them in the order of their availability, giving in detail the amount of power to be developed in each case, the cost of the development and of maintenance, and the probable revenue to the State. In its final report the Commission was directed to submit a draft of a general law providing specifically for the development of water power by the State. As outlined by the act, this general law must provide for a bond issue to be authorized separately for each separate improvement and a tax upon the property benefited suficient to pay the interest and principal of the bonds.

"This plan follows the plan adopted by the National Government in the reclamation of the arid west, under which the money advanced is repaid into the treasury.

"The Fuller Act distinctly contemplates the sale of the power developed by the State upon terms to be readjusted at suitable intervals. It appropriated $35,000 for beginning the work of investigation.

"In the same session of the Legislature the State again definitely committed itself to the policy of demanding payment for water power franchises. Application was made by a corporation for authority to construct an electrical power plant on the Long Sault rapids in the St. Lawrence river. The Governor refused to sign the bill unless provision was made in it for payment to the State of compensation upon a sliding scale in proportion to the amount of power developed and such provision was made.

"Detailed studies of the most important water power sites having been completed by the Water Supply Commission, it reported to the Legislature of 1910 a bill for a comprehensive general law, providing for the issue of bonds as required up to a total of $20,000,000, for the sale or lease for stated terms of the water or power developed, and for the annual assessment of property benefited. The bill after receiving the signature of the Governor, was to be submitted to the people, and could not become effective until approved by the people at the polls.

"This bill was opposed by the existing water power interests, and their opposition was strong enough to kill it. Nevertheless the need for more water power development in the State is so great, that they succeeded in inducing the Legislature to pass another bill which attempted to give to them what they desired by amending the River Improvement Act. The provisions of this bill were so plainly opposed to the interests of the people at large that Governor Hughes vetoed it.

"The plans devised by the State Water Supply Commission involved the necessity of flooding a small area of the forest land belonging to the Adirondack Park. But a provision of the State constitution whereby the Adirondack Park was created prohibits the removal or destruction of any timber whatever within the confines of the Park. This provision (now known to have been altogether shortsighed, inasmuch as it not only blocks water power conservation, but also actually defeats its own purpose by preventing scientific forest management within the park) cannot be set aside without the adoption of a constitutional amendment; and as yet the assent of the people to this amendment has not been secured."

This statement was made about four years ago. In July, 1911, the law known as the Conservation Law was enacted. This law created the Conservation Department, and the State Conservation Commission to be the administrative body to carry out the provisions of the law. The Commission consists of three members, at an annual salary of $10,000.00 each; and it superseded a number of other boards and commissions, including among them the water supply commission.

A bill drafted by this Commission was introduced into the Legislature in February, 1912. In brief, this bill provides that—

> "The Conservation Commission is authorized to acquire by purchase, lease, or condemnation, lands, water privileges, and water rights, and to use and develop the same. It is also empowered to construct transmission lines for the purpose of delivering electrical energy to the various municipalities throughout the State. It may likewise purchase electrical current from a private producer, or transmit the same to any point for such producer, at a price fixed by the Commission. It further provides that such municipalities are authorized to enter into contracts with the Conservation Commission for the use of power so transmitted. Each municipality is required to pay its proportionate share of the cost of production and transmission, including a charge for interest, upkeep, maintenance and operation, with an amount sufficient to amortize the investment in from thirty to fifty years. The maximum cost to the ultimate consumer is fixed by the Conservation Commission. Before any municipality shall enter into such contract, it must be approved by a vote of the people.
>
> "In other words, the agency of the State is used for the production and transmission of electrical energy to the various municipalities, which undertake the distribution thereof to the consumers, the purpose being to furnish light for its public streets and buildings, commercial and domestic use, and power for manufacturing and traction purposes, at cost.
>
> "In case there is a private distributing company operating in such municipality, such company is authorized to enter into a contract with the municipality for the distribution of electrical energy at a price to be fixed by the commission. In case the municipality refuses to enter into such contract so determined by the commission, its application for power will be denied. The purpose of this provision is to protect honest capital invested by private persons in electrical enterprises.
>
> "In the event that the efficient development of unused water power involves the regulation of stream flow by impounding flood waters or otherwise, the Commission is authorized to enter into agreements with the owners of developed powers to pay the State for the benefits derived therefrom. This is regarded as a practical and business-like method of improving the power capacity of our streams, and will greatly increase the power at developed sites at a minimum cost to owners.
>
> "In a word, the general scope and scheme of the statute is aimed at the utilization of the undeveloped water powers of the State, the dis-

tribution thereof to the various municipalities, which in turn serve the same to the ultimate consumer at the cost of production."

The bill had the hearty support of the Governor and was passed by the Senate, but was killed in the House. Sooner or later an aroused public interest will undoubtedly force the passage of this bill.

NEW JERSEY.

While the State of New Jersey has practically no water power resources, its attitude towards water supply is fully abreast of that of any State. In 1907 a law was enacted creating a State Water Supply Commission, charged with general supervision over all sources of potable and public water supply. The Commission is also empowered to build reservoirs and other regulating works within the boundaries of water supply districts to be established by act of the legislature. When built, the Commission is required to maintain such works, and is authorized to sell or lease power to be derived from the flow of water at or near any dams included in the regulating works, at a rate agreeable to the Commission.

Since the passage of the law of 1907, several supplementary laws have also been passed, all tending to strengthen the jurisdiction of the Commission, until now a complete system of water conservation and distribution is in full effect. A number of large storage reservoirs will soon be built by the State for municipal water supplies.

CALIFORNIA.

In April, 1911, an Act was passed regulating and limiting the appropriation of water power and creating a Water Supply Commission, and this Act was finally amended in January, 1912, to the present law. This law provides, among other things, that water or the use of water for the generation of electricity or other power shall be appropriated for a period of not longer than 40 years; that all appropriations shall be made subject to the right of the State to regulate and fix the rate of compensation for which such power may be sold, rented or distributed, and subject to repeal for non-use. It provides that no appropriation shall be made without a permit from the Commission; that the Commission shall not grant a permit for the appropriation of more water or the use of more water than can be applied efficiently and economically to the use for which application is made; and that the Commission shall not grant the permit at all if in its judgment such grant is contrary to the public interest. It provides that actual construc-

tion work shall begin within six months from the date of granting the permit, and shall thereafter be prosecuted with reasonable diligence; and such work shall be completed within a reasonable time as fixed in the permit, not to exceed five years, unless for good reason the Commission extend the time for one additional year. Upon completion of the works the use of the water shall not be permitted until the Commission shall approve the same. An extension of the grant for a second period not to exceed forty years is provided for. All appropriations of water or the use of water shall be subject to the imposition of fees and charges by the State as follows: A fee of $10 upon the filing of application for permit; a fee of $100.00 upon the granting of such permit, and in addition to this an annual charge for each theoretical horse power as follows: For the first 100 horse power, no charge; and for all above 100 horsepower 10 cents for each horse power. The act further provides drastically against combinations in restraint of trade or mergers of any deleterious kind. Finally, the act declares any violation of the act or of any order or regulation of the Commission to be a misdemeanor, and punishable as such.

IDAHO.

The law of Idaho declares that any use of water essential to the completed development of the material resources of the State is a public use and as such is subject to the regulation and control of the State, such control extending to the fixing of charges by the State. The law makes the State Engineer the executive officer through whom the strict supervision and control of all dams, reservoirs and other works for the utilization of the water resources is effected. The law provides that all rights of way for canals, etc., shall be approved both by the State Engineer and by the State Board of Land Commissioners. It provides that State lands suitable for reservoir sites may be reserved by the State for storage purposes. And, finally, it provides that all water rights shall be forfeited for non-use for a period of five years, and that any work of construction to utilize water shall be completed within five years of the application for the water-right.

MAINE

In 1909 the Legislature passed a law creating a State Water Storage Commission consisting of the Governor, the State land agent, and three citizens appointed by the Governor. The com-

mission was directed to appoint an engineer, and to proceed as follows:

(1) To collect information relative to the water powers of the State, the flow of rivers and their drainage areas, etc.,

(2) To report a comprehensive and practical plan for the improvement and creation of such storage reservoirs as would tend to develop and conserve the water powers of the State.

(3) To report on the existing development of the water powers of the State.

(4) To prepare full hydrographic and other data for all such water storage basins as the commission should be able to devise plans either to improve or create; and to make estimates of the increase in power that would be developed by the proposed dams and reservoirs.

(5) To ascertain what townships or parts of townships could be purchased by the State and the cost thereof for use as a forest reserve or for conserving the water powers of the State.

(6) To investigate the question of denuded, burnt over or barren lands, their extent and value, with a view to their purchase for reforestation.

(7) To present said report to the Legislature by January 15' 1911.

An amount of $5,000.00 a year for two years was appropriated for the work—"an amount wholly insufficient for the tasks set forth."

In compliance with the Act of 1999, the Water Storage Commission made a report to the Legislature of 1911, in which, after quoting from a speech made by Herbert Knox Smith, U. S. Commissioner of Corporations, made before the National Conservation Congress, the recommendations given below were made. The quotation from Mr. Smith is as follows:

> "Effective restraint imposed by competition on the control of water power is becoming more and more improbable. There has been a marked concentration of water power control in private hands, and this process is advancing rapidly. Public regulation of water power, the only other alternative, therefore, becomes a necessity.
>
> "Consolidation of water powers within a marked area has certain practical and economic advantages. In some cases it is an actual conservation of power.
>
> "Suppose there are two independent power plants in two neighboring communities where the demand in one community is mainly for power during the day time and in the other at night. These plants can advantageously combine, throwing the surplus of their joint power by day

to one place and by night to the other, thus bringing their normal load in each case up nearer to the peak. Similarly, such coupling up is obviously advantageous in two neighboring water sheds where the excess water power occurs at different times.

"We have no reason to oppose such combinations of varying conditions if it is accomplished by fair methods. We must simply be prepared to regulate such monopolistic power as may result therefrom.

"The situation in the hydro-electric industry is, in brief, as follows:

"*First*, It deals with the basic necessity, and its importance inevitably increases as the fixed supply of sources of other power decreases.

"*Second*. Substantial control of mechanical power means the exercise of a function that is governmental in its effect on the public.

"*Third*. Driven by underlying economic and financial forces, concentration of control of water power in private hands has proceeded very rapidly. It is doubtful if anything can arrest this process, and a swift advance to a far higher degree of concentration is entirely possible.

"*Fourth*. Any chance, then, of restraint by competition is rapidly disappearing, certainly over given sections, and public regulation therefore, are an imminent necessity.

"The nation and the State will have to use their full powers to meet the water power situation. The most effective time to use them is before, not after, private rights accrue. The one certain method is for the State or federal government, to retain its interest, or impose its conditions at the inception, as a part of the grant. Then public control and private rights go together, as they must if we are to safeguard the public interest in water power.

"Let there be no unnecessary hampering of hydro-electric development, but let the public be in on the ground floor at the start, for at the start the public must grant the power and for all time the public will be the party chiefly interested in its use.

"Specifically:

"*First*—The *status quo* of powers still controlled by the nation or state should be maintained until we know what we have, and can act intelligently thereon.

"*Second*—No grant should be made except for a fixed period, with at least the reserved right to readjust terms at the end thereof. That period, however, should be long enough to permit adequate financing and complete development.

"*Third*—Complete publicity of accounts and transactions should be required as well as a record of cost, and the real relation of investment of stock and bond issue.

"*Fourth*—Power to revoke the grant for breach of conditions should be lodged in a specified authority. Otherwise there will always be the possibility of protracted litigation to determine the status.

Fifth—So far as is possible, direct provision should be made against excessive charges and monopolistic abuse.

"*Sixth*—Public authorities should reserve such constitutional compensation or rental as will establish the principle of underlying public interest.

"*Seventh*—All public easements of navigation, fisheries, etc., should be safeguarded.

"*Eighth*—In case of new grants, all these provisions should be made conditions of the grant.

"FINALLY, the purpose and probable effect on the public of any grant should be first fully ascertained and carefully considered, in order to determine whether public interest justifies beyond a reasonable doubt the surrender by the public of even a part of its power over this great public resource. Where reasonable doubt exists, the *status quo* should be maintained."

The recommendations of the Commission were as follows:

"*First*—To require every person, firm or corporation, contemplating the construction of a dam for the storage of water or the development of water power in the State, to submit their plans to the Commission and obtain the approval of the Commission before beginning the construction.

"*Second*—To require every person, firm or corporation applying for a charter for the development of storage or water power, to submit their plans to the Commission for approval before beignning construction; to provide for practically the same requirements in the case of agreements for the merger or consolidation of two or more corporations for the same purpose; to require the approval of the Commission in all cases of sale, assignment, disposition or transfer of any franchise of a company formed for the development of storage or water power.

"*Third*—To assess and collect fees annually for all franchises of water power which may be granted hereafter by the State, the amount of assessment being on a sliding scale and based either on the gross receipts of the company, or on the horse power proposed to be developed.

"*Fourth*—To assume control and regulation of all reservoirs now built or that will be built by private parties on lands in part or in whole controlled by the State, known as public lots or State lands, and on all great ponds and lakes of the State, taking care in such legislation not to injuriously affect vested rights."

The only action taken by the Legislature of 1911 was to revise the laws of 1909 by consolidating the Water Storage Commission and the State Survey Commission. The recommendations above had been formulated into a bill by Mr. C. C. Babb, the Chief Engineer of the Commission, but the bill was introduced too late in the session to receive consideration.

"The bill is founded largely upon a decision of the Supreme Court of the State (90 Maine, 577) as follows:

"The waters of the great ponds and lakes are not private property; the State owns the ponds as public property held in trust for public use;

> it has not only the ownership of the soil, but also the right to control and regulate the public uses to which the ponds shall be applied; the authority of the State to control waters of great ponds and determine the uses to which they may be applied, is a governmental power and the governmental powers of the State are never lost by mere non-use."

The bill has not yet been enacted into law.

PENNSYLVANIA.

The laws of Pennsylvania relating to water and water power companies are too lengthy for even a complete digest to be made here; they may be found codified in the Annual Report of the Water Supply Commission of that State for 1909, wherein they occupy 77 pages. For our purpose it is sufficient to cite those laws whereby the State has established its system of conservation of water and water power.

The first of these is the Act of April 13, 1905, which states that "No water or water power company, hereafter incorporated under any law, shall have power or exercise the right of eminent domain, as respects the appropriation of the streams, rivers or waters of this commonwealth, or any of them, nor the land covered thereby." This act affects all water and water power companies incorporated subsequently to its passage.

On the 4th of May, 1905, an Act was approved by which the Water Supply Commission was created. The Commission consists of five members, the Commissioner of Health, the Commissioner of Forestry, and three others appointed by the Governor. The Act gives the Commission jurisdiction over the water supply of the State, directs them to employ an engineer and such other assistants as are necessary, provides that no water company shall be thereafter incorporated without the approval of the Commission, directs the Commission to collect information relative to the water supply of the State and to recommend future legislation for the conservation, etc., of the water supply, and finally appropriates $40,000.00 to the use of the Commission.

The next Act is that of May 28, 1907. This law provides that no dam, wall, pier or other obstruction shall be built by any person or company without first securing the approval of the Water Storage Commission, nor in any manner shall they change or diminish the course, current or cross-section of any stream declared by the State to be a public stream without such approval.

The third is that approved on the 7th of June, 1907. This law

is entitled, "An Act to require all water and water power companies hereafter incorporated, or hereafter formed by merger and consolidation, or hereafter purchasing the property and franchises of any other such company, to designate the exact source of their supply of water or water power; and to require all existing water and water power companies, merging and consolidating or purchasing the property and franchises of any other such company, to accept the provisions of this act, and of the act approved April thirteenth, 1905, entitled An Act providing that the right of eminent domain, as respects the appropriation of streams, rivers or waters, or the land covered thereby, shall not be exercised by water companies incorporated under law, and providing the manner in which water and water power companies, subject to the provisions of this act, may secure a new or additional source of supply for their water or water power."

Section 1 provides that from and after the passage of the act no application for a charter for a corporation for the supply of water or water power shall be approved by the Governor unless said application has first been submitted to and has received the approval of the Commission; nor unless the said application shall contain a statement of the name of the stream from which it is proposed to take or use water or water power, and the location of points on said stream between which it is to be taken.

Section 2 provides that no agreement for the merger and consolidation of two or more corporations whether formed prior to or subsequent to the passage of this law for the supply, storage and transportation of water or water power shall be approved by the Governor unless said agreement shall first have received the approval of the Commission, nor unless the agreement shall stipulate that the parties thereto forfeit and surrender the right of eminent domain, nor unless each of the parties thereto shall have filed with the Commission a written acceptance both of this act and that of April 13, 1905, agreeing to be subject to and bound by the provisions of both of the acts with like effect as if said corporations had been formed subsequently to the passage of both of said acts.

In Section 3 provision is made that no sale, transfer, assignment or conveyance of the franchises or property of one corporation to another corporation shall be valid except in accordance with conditions similar to those laid down in section 2 for consolidations.

Section 4, finally, provides that no new or additional source of supply for its water or water power may be drawn upon by any company or corporation except upon conditions similar to those enumerated in section 2, and providing further that such privileges shall not be granted if their granting would be prejudicial to the interests of the State in such source of supply if needed for the promoting of any system of inland navigation.

A fourth act, approved June 15, 1911, was passed which has to do with the time within which water or water power companies shall begin and complete their works. It requires the approval of the Water Supply Commission to any extension of time for beginning construction beyond two years and for completing beyond five years, and provides for the annulment of charters of companies violating this law.

OREGON.

A water law was passed in 1909 which places the control of the streams in a Board of Control headed by the State Engineer. Proof of appropriation of water is made to the Board of Control with payment of a fee of $1.00 for recording the water right certificate, and 25 cents for each theoretical horse power up to 100, and 15 cents for each horse power up from 100 to 1,000, 5 cents for each horse power between 1,000 and 2,000 and 2 cents for each horse power in excess of 2,000 horse power. The law in full follows:

An Act providing for granting franchises of water power by the state, and collecting fees therefor.

Be it enacted by the people of the State of Oregon:

Section 1. All water within the state from all sources of water supply belongs to the public.

Section 2. That every person, firm or corporation, except municipal corporations (hereinafter called the appropriator), who shall appropriate water after the passage of this act, for the purpose of applying the same to the development of power, shall during the life of such appropriation as fixed herein pay to the State of Oregon not less than twenty-five cents or more than two dollars per annum in advance, on or before the second day of January of each year, for each and every horse power represented by the said appropriation. The amount of the payment shall be determined by the Board of Control, and adjusted from time to time, based upon the percentage of power appropriated which is put to beneficial use. For the purpose of this act, a horse power is hereby defined to be 550 pounds of water per second of time for each foot of available fall.

Section 3. The appropriator shall pay to the Board of Control the fees required by Section 2 of this act, proportionate to the remainder of the current year, and no appropriation of water for power purposes shall be deemed complete until such payment of fee is made. Immediately upon receipt of such fees the Board of Control shall pay them over to the State Treasurer, taking his receipt therefor, who shall place the same in the general fund of the State treasury. On or before the second day of January of each year thereafter, every appropriator of water for power purposes shall forward to the Board of Control the fees provided for in Section 2 of this act.

Section 4. Upon the completion of the appropriation of water for power purposes, as now or hereafter provided by law, and compliance with the provisions of this act, the appropriator thereof shall own and enjoy all the uses thereof so long as he pays the annual fees therefor, herein required for a term not exceeding forty years from the date of appropriation, and shall have a preference right to reappropriate such water under such conditions as may be prescribed by law at the expiration of such term of years provided all fees shall have been paid. If any appropriator shall fail to pay any annual fee, or shall fail or refuse to renew the appropriation at its expiration, the State shall have a preference lien therefor prior to all other liens or claims, except for taxes, upon the improvements of the appropriator for developing and applying such appropriation of water and the real estate upon which the same are located, and upon notice from the Board of Control, the Attorney General shall proceed to foreclose the lien and collect any unpaid fees in the same manner as other liens or real property are foreclosed, and the water shall be again subject to appropriation.

Section 5. Any person, firm or corporation who believes himself or itself injured in any material right by any decision of the Board of Control shall have the right of appeal from such decision to the circuit court for the county in which the proposed appropriation of water is situated.

Section 6. In case the Board of Control is not created by law, with power to supervise the appropriation, distribution and use of the water of the State, then the duties imposed upon the Board of Control, as prescribed by this act, shall devolve upon and be assumed by the State Engineer.

Filed in the office of the Secretary of State February 24, 1909.

WISCONSIN.

The water power law of Wisconsin, enacted during the session of 1913, is the outcome of some years of agitation for State control and ultimate ownership of water power development. A law to effect this end was passed by the Legislature of 1911, but among its provisions were some of doubtful constitutionality; and in January, 1912, the State Supreme Court annulled it upon the grounds of unconstitutionality. The present law follows closely

its predecessor, omitting, however, the provisions to which exception had been taken.

The law vests the administrative control of all water power, whether developed or undeveloped, in the State Railroad Commission. In brief, it provides the conditions under which the Commission shall grant charters or franchises, limits the terms of such franchises, provides against the possibility of unlawful combinations, trusts and agreements whereby to limit the output of power or control its price; fixes a nominal annual charge for franchises; provides for the State or for municipalities taking over water power developments by condemnation, if after a definite period has elapsed the public good requires it; and provides that compensation shall be for the full value of the comdemned property, but allows nothing for the franchise value in the event of such taking. Nominally the law relates to water powers in navigable streams only, but there is in it one clause which apparently virtually extends the control of the Commission to all water powers.

More in detail, the law may be paraphrased as follows:

The Railroad Commission is authorized to employ a Hydraulic Engineer and such other assistants as may be needed; to make a complete hydrographic survey of all navigable rivers; to inspect and control all river improvements and water power developments; to investigate all existing dams and franchises; to approve all locations and plans for the building of dams and all plans for the improvement of existing plants, and to supervise the work of construction and the operation of the same; to regulate the level and flow of water in navigable streams; to supervise the methods of accounting and approve expenditures and outlays of water power companies; to approve contracts for the sale of water power, and to approve the price paid for water power property and the price paid for the construction of power plants. The law specifies that all dam owners except municipalities shall pay an annual fee not to exceed 10 cents per theoretical horse power of capacity of the plant at ordinary river stage; and after the expiration of 30 years from the passage of the act, it provides that the State may increase the amount of the annual fee collected. The owners of dams are required to maintain the dams and all appurtenances in good repair, subject to constant supervision by the Commission.

At the expiration of the 30-year period the Commission may require that any power which has been sold and transmitted out-

side the State or at distances within the State remote from the power site, shall be sold and delivered within the State, at points reasonably near the dam site.

The grantee of a franchise must agree to develop at the selected site all the power that can be developed there, and to install auxiliary steam power if so directed by the Commission. Franchises may be granted to residents of the State only. Franchises may not be transferred or assigned to any foreign corporation, nor will any transfer or assignment be valid unless with the approval of the Commission.

Franchises for the development of power at a site where more than 250 horse power is susceptible of development shall not be granted except to municipalities or to corporations organized under this law, and then only for the improvement of navigation and the development of power for sale to the public. Any water power development may be acquired for public municipal purposes by any municipality by condemnation proceedings. In appraising a water power property no allowance shall be made for the value of the power site as such, or for the franchise value. At the expiration of the 30 year period the State (if it shall have the constitutional power) may acquire the property of the corporation at the cost of then reproducing the plant, as determined by the Commission. The clause of the law prohibiting mergers and combinations in restraint of trade reads as follows:

> "If any improvement, maintained under any franchise granted pursuant to the provisions of this chapter, shall be owned, leased, trusteed, possessed, or controlled by any device permanently, temporarily, directly, indirectly, tacitly, or in any manner whatsoever so that the same form a part of, or in any way affect any combination in the form of an unlawful trust, or form the subject of any contract or conspiracy to limit the output of any hydraulic or hydroelectric power derived therefrom, the State may take possession by proceedings instituted by the Commission as in cases of receivership, and in such proceedings the members of the commission shall be appointed to act as receivers during such period as the court may determine."

UNITED STATES REGULATIONS COVERING WATER POWER DEVELOPMENT WITHIN FOREST RESERVES.*

Water power permits are given, but these convey only the privilege of occupancy and use of land. No attempt is made to adjudicate water rights since these are acquired under State laws and adjudicated by the courts. Water power permits ordinarily terminate at the expiration of 50 years, but the expiring permit is held to be an application for a new permit to occupy and use the land mentioned in the original.

"Preliminary" permits are made to allow the occupancy of the land within national forests for securing data required in making an application for final permit and for such construction as is necessary to preserve water appropriation during the early period. Only the final water power permits allow the occupancy and use of land for construction, maintenance and operation of works, the main purpose of which is generation of electric power.

There is a class of development termed "non-commercial water power" work, covering developments used solely for the operation of mines or in the milling and reduction of ores, as auxiliary to irrigation works, temporarily in the construction of other works for which privileges have been granted, or for municipalities and municipal purposes.

No charge is made for occupancy and use of land for non-commercial work. For commercial projects the permit is conditional on the payment of an annual charge based on the value for power purposes of such land, the measure of value for power being the "net power capacity" of the work. The rates of charge for each net electrical horse power per year vary from 10 cents to $1.00 for the first ten years and remain constant at $1.00 for succeeding years.

The "net power capacity" on which charges are based is determined by the following deductions from "gross power capacity" of the entire works: (1) An amount bearing approximately the same ratio to the storage power of the reservoir or reservoirs as the area of unreserved and patented lands within the flood lines bears to the total area within flood lines; (2) an amount bearing the same ratio which the difference between gross power capacity and patented lands bears to the total length of conduit; (3) a further de-

*From *Engineering News*, Vol. LXVIII, p 844.

duction amounting to the square of distance of primary transmission multiplied by the factor 0.001, the deduction not to exceed 25 per cent, however.

The "gross power capacity" from which deductions are made is interpreted to mean the power capacity of the entire works to be constructed, maintained, or operated under the permit, based on the estimated average annual station output in electrical horse power under continuous operation, with a reasonable load factor and with the use of all available water falling through the maximum effective head, with proper deductions for reasonable mechanical and electrical losses in the generating machinery.

Preliminary permits are granted usually for a period not to exceed two years, though they are drawn up according to the circumstances of each particular case. When the time prescribed by State statutes, in which construction must begin in order to maintain water-rights, is insufficient to prepare a final application before beginning construction, a clause is inserted in the preliminary permit allowing construction to proceed to an extent sufficient to permit compliance with State law. To prevent speculators holding the sites under preliminary permits, an annual charge is made during the term of the preliminary permit calculated on the basis of the estimated capacity of the proposed works and at the rates already noted. When the final application is filed in accordance with the terms of the preliminary permit, payments made under the preliminary permit are credited upon payments to become due under the final one.

On the failure of a permitee to comply with the terms of a preliminary permit, the preliminary permit is terminated and no other application covering the same or adjacent lands is received from the same applicant for one year subsequent to the termination.

On receipt of an application which is in whole or in part included in an existing permit, the applicant is informed of the conflict and he is given an opportunity to amend his application to avoid the conflict, or he is enabled to renew his application at the termination of any existing permit which may be lost.

APPENDIX B.

DIGEST OF PROCEDURES AND LAWS OF OTHER COUNTRIES WITH REFERENCE TO WATER POWER.

CANADA.

In May, 1906, the Legislative Assembly of the Province of Ontario enacted a law "to provide for the Transmission of Electrical Power to Municipalities." It is called the "Power Commission Act."

This law created the Hydro-Electric Power Commission of Ontario, to be the executive body to carry its provisions into effect. The Commission was directed to inquire into "the present and probable demand for electric power in the various districts capable of being supplied from the water powers of the Province; the location, capacity and cost of development of the undeveloped water powers; the cost of the electrical transmission of power; the rates that must be charged for the sale of power; the capital cost, present value, etc., of the existing developments."

Among other things, the act provided that upon application being made to the Commission for power by any municipality, the Commission should ascertain the rate at which such power could be supplied, and if the power were required, should enter into contract to supply the municipality therewith. The Commission was empowered also to supply power to railway companies and distributing companies.

The act further provides that the Lieutenant-Governor is empowered upon recommendation of the Commission to authorize the Commission from time to time to purchase, lease, or expropriate without the consent of the owners thereof any existing water power development or transmission line or other works or property deemed necessary for the purposes of the Commission.

Provision is made whereby the municipalities receiving power shall pay only the cost of the same; but this cost includes the proportionate share of interest at 4 per cent. on capital costs, of a thirty year amortization of such cost, and of the cost of operation, maintenance and insurance of all such works as the Commission may need to construct or acquire. The Commission fixes the rates

at which power shall be resold by the municipalities or the distributing companies supplied.

The act provides that municipalities, towns and villages may, by referendum vote, raise money by the sale of bonds for the purpose of erecting such works or distribution system as may be requisite for receiving and utilizing such power as the Commission contracts to furnish to it.

In 1907, the act was amended in certain minor details. In 1908, an act was passed validating all contracts made by the Commission, including the now famous contract for 100,000 horse power to be supplied to the Commission by the Ontario Power Company of Niagara Falls, and including also contracts with nineteen cities, towns and villages for power to be supplied to them by the Commission.

In 1909, and again in 1910, acts were passed further elaborating and perfecting the Power Commission Act.

In 1911, a supplementary act was passed which provided that any tax payer living within any corporation not already supplied with power by the Commission may require the Council of the Corporation to make application in his behalf for a supply of power. The act makes it mandatory upon the Commission thereupon to furnish an estimate of the cost at which such power can be supplied; and if such cost be acceptable to the applicant, the Corporation is required to enter into contract with the Commission to receive such power without first submitting the matter to a vote of the citizens of the Corporation.

The Power Commission Act of 1912 further enlarges the powers of the Commission so as to enable it to undertake the improvement and conservation of water powers and water privileges by storage works, etc., and to enable it to acquire by purchase or expropriation the whole or parts of distribution plants in municipalities which have entered into contracts with it for the supply of power, and to turn the plant acquired over to the municipality. The act extends the power of the Commission as to regulating the construction, equipment, etc., of electric light and power plants and services, practically placing the whole matter of the standardization of electrical equipment within the Province under the control of the Commission. It further gives to the Commission the control of rates and the methods of book-keeping by municipal corporations operating distribution plants, and the power to di-

rect the application of surplus receipts to one of the four accounts specified in the act. A fine of $100.00 a day is assessed against any corporation, company or individual for refusal or neglect to obey and carry out any order or direction of the Commission.

The Commission is empowered to require either electric light, heat or power companies or telegraph or telephone companies to discontinue the use of overhead wires and to carry the wires in underground conduits wherever in the opinion of the Commission the protection of life or property or the convenience of the public so require.

All of these enactments have had the same trend; namely, to strengthen the powers of the Commission and to extend its field of activity and usefulness.

With a total expenditure of less than five million dollars, the Commission is now supplying electricity to over thirty-six municipalities, including the city of Toronto, with a population of over 400,000, Ottowa with 90,000, Hamilton with 82,000, and London with 48,000. It operates about 300 miles of high tension and 100 miles of low tension transmission lines and maintains a large mileage of distribution lines radiating from them. About 100 applications are now waiting further extensions of this system before they can be filled. The cost of electricity to the ultimate consumer has been materially lessened, being in many instances cut in half, with the result for example that in the City of Ottowa electric lights are found in 98 per cent of the homes. Of the population of Ottowa, one out of every five of the inhabitants is a customer for electricity. By way of contrast, in Buffalo, N. Y., one out of every 37 inhabitants consumes electricity, and in New York City, one out of every 35. In Winnipeg, the cost of domestic lighting has been reduced from 20 cents per kilowatt-hour to 2.4 cents per kilowatt-hour; and electricity is sold for cooking at the special rate of 1 cent per kilowatt-hour. In addition to the system now being supplied from Niagara, seven other districts are now being served, or plans are under way to serve them. The following is quoted from the Second Annual Report of the New York State Conservation Commission, pp. 135-137:

"The work carried out by the Commission is a model of substantial, permanent, economical and completely successful construction. The system is a pronounced physical, economic and financial success, and is up to the last minute, or leads, in every detail.

"The results of the operations of the Hydro-Electric Commission are:

1. The householder, merchant and manufacturer are getting double the power at the same total cost as formerly paid.

2. The cities and villages are much better lighted than before at less total cost.

3. The per capita cost of distribution plants in the cities varies from $5 to $10.

4. At least in those places where results are available, the incomes are sufficient to cover all charges, so that these results have been attained without the imposition of any additional taxes.

5. With increasing use, decreasing charges will be possible, so that further reductions in rates are practically certain to follow.

6. In nearly all cases these results have been achieved without detriment to local companies, so far as can be judged by their reports and the prices of their securities.

7. The savings to the consumers during the first year of operation have been estimated at $2,000,000.

"The competition and the example of the Hydro-Electric Commission has led to increased efficiency in the management of competing private companies. Having a monopoly, and the ever-present fear of showing too great earnings, there had been little inducement for the old companies to apply the principles of scientific management to their business. Current was sold on the basis of what the traffic would bear. The hydro power is sold on the basis of cost of service, and in meeting the competition the companies have adopted the same rates, with the result that undesirable contracts costing more than they returned have been eliminated. In other matters than rates, the analysis and study induced by real unescapable competition have shown where large benefits can be secured at little or no cost. The competition is not intended to be destructive on the part of the municipalities, but simply regulative, and has resulted in healthy tissue in the place of the dry rot induced by monopoly.

"To bring these results to the homes and business of a million people has required the use of a surprisingly small quantity of power, the maximum thus far (October 1, 1912) used on the entire Niagara district system having been less than 28,000 horse power.

"Anyone looking for something from which future disaster to either the provincial hydro-electric scheme or the municipal dis-

tribution of the energy can be predicted, is likely to be disappointed if he gives fair consideration to the facts as they exist, and the general economic problems that the scheme is designed to solve. It needs no professional to see that mechanically the lines and works are of the highest order of excellence, while the few interruptions to service show their efficiency. The excellence of the installations is too apparent to be disputed, and even those hit hardest by the competition introduced are compelled to admit this feature of the hydro-electric scheme. Proof of the superior quality of the Hydro-Electric Commission's plant was furnished on July 5, 1912, when a severe electric storm put the equipment of the Toronto Electric Company out of service for five hours and fifteen minutes. The street railway and lighting systems of the private companies were shut down, but no interruption of the service to customers of the hydro system occurred.

"With all these features of excellence and success, there is coupled that of financial stability. The general system has met all of its obligations, and has $50,000 laid aside for depreciation account. At the same time the contracting municipalities have been treated leniently, and the last cent has not been required in any case. An example of this is the non-enforcement of the clause of the contracts requiring the cities to pay for three-fourths the amount contracted for whether used or not. The amount used has been the basis of payment in every case."

ITALY.

The following summary is taken from the Report of the Minnesota State Drainage Commission:

The waters (except very small streams) are public property, franchises for development being issued by the national government. The franchise stipulates the conditions, use and rental and the quantity of water granted. It stipulates the requisite guarantee in favor of agriculture, industry or public health. The period within which the development must be made is fixed. Franchises must not be granted for more than thirty years, but can be renewed. Provision relative to safety is made for closing of gates during floods, etc.

If during the life of the franchise the regimen of the water course is changed in the public interest, the nation is not held to any indemnity in favor of the grantee, who in such event has a right

merely to a proportionate reduction or cancellation of rental. The rental (presumably annual) is fixed at 55 cents per horse power in industrial divisions.

Where two applications for a franchise are made preference is shown the first applicant. The higher rights of the nation may either oppose an individual application or accord the preference to a later applicant among a number of concurrent applications.

In connection with the foregoing paragraph, proposed legislation is as follows:

Whenever application is made for a franchise for a power development, an examination by a permanent special commission shall be made to determine whether any legitimate public interest or any present or future need of the nation interferes with the granting of the franchise. If the decision of said commission is favorable, the examination of the application in the regular manner immediately follows. If the decision is unfavorable, the minister of public works shall, after consultation with the higher council and the council of state render a decree deciding whether the examination of the application shall proceed. By means of such a decree, the minister can, if necessary, ultimately prevent all concessions to individuals in a certain river basin, section or lake over which he has control.

If the nation finds it desirable to utilize or to reserve any water powers for the sake of public service, the competent administration, or a deputy named for that special purpose, shall present a preliminary plan containing a technical exposition of the purpose, nature, object and utility of the work to be established or of the reservation. This plan shall be submitted by the minister to the permanent special commission aforesaid, and in accordance with its advice and that of the higher board of public works, after consultation with the council of state, he shall decide by a special decree the appropriation or reservation of the power privileges required for public service. In case an affirmative decision is reached, individual claims that are inconsistent with the government project shall be nullified, irrespective of the state of advancement of construction.

In order to reduce the chances for monopoly and speculation the proposed law stipulates as follows:

The grantee of a water right can be authorized by a decree of nvestiture to form either a syndicate or a civil or commercial

company for the exploitation of his franchise, provided he remains connected with it up to the time of the organization of the company, and provided that the organization is effected within a period of six months from the date at which the grant went into effect. It is forbidden, under penalty of forfeiture, to transfer to a third party a franchise for a water right in any other manner before such franchise shall have been entirely utilized.

The conclusion of the same article contains the following new condition relative to municipal franchises:

Municipalities may reconvey to third parties the development of water power rights vested in them for the benefit of public service, such as electric lighting, railway traction, and for domestic or hygienic purposes, provided they follow a simple system of reimbursement of expenses of development over and above the interest and amortization of capital used, to the total exclusion of all speculation. No streams can be used without a permit from the government and then only upon payment to the government. All rights to the use of water power development are limited to a reasonable period. Applications for permits are considered by a special commission, which may refuse the permit where the use to which the water is to be put is regarded as inferior to some other possible use.

SWITZERLAND.

After some years of agitation in favor of governmental control of water power, an amendment to the federal constitution to provide for such control was first favorably passed upon by the Federal Assembly, and was then submitted on October 25, 1908, to a referendum vote of the people. The amendment was carried by the decisive vote of 305,000 to 56,000.

In accordance with this amendment, the utilization of water power passed under the supreme supervision of the Confederation, the provisions of the legislation being briefly as follows: Federal legislation shall prescribe the general regulations which shall be deemed necessary to safeguard the public interest and to assure the wise utilization of water power. Full regard shall be paid to the interests of internal navigation. When a section of a stream needed for a single power project forms a part of the boundary of the country itself or of two of the cantons (the cantons correspond to our states), authority for granting a franchise for its utilization lies wholly with the central government, and the central govern-

ment fixes the fees and rental chargeable for its use. Provision is made, however, for a hearing to be given to the cantons especially interested. When the power site lies wholly within one canton, the regulation of it and the granting of the franchise rests with such canton, subject however to the general regulations of the central governing body. The transmission and distribution of electrical power is subject to control by the Confederation, and it may by no means be transmitted out of the country without specific authorization from the central government, and then only for a limited period.

For the purpose of elaborating the details of these simple requirements, a commission of experts, a galaxy of very distinguished engineers, counsellors of state, chief justices, professors and others, was brought together, and nearly three and a half years were consumed by the deliberations of this august body. To harmonize the action of the central government with the divers laws and regulations already in force in many of the cantons proved to be a perplexing task; and to mete out justice to all, to stimulate the prompt utilization of all the available water power of the country, and yet to protect the people against excessive charges for their meed of power, and to prevent financial manipulations and speculation, altogether called for a high order of statesmanship in perfecting the final draft of the regulations. The final law was promulgated on April 19, 1912. A careful reading of this law cannot fail to impress one with the reasonableness of its provisions. The law numbers 64 articles, grouped into four chapters, entitled respectively: (1) The Right of Disposition; (2) Utilization of Water Courses; (3) Concerning Water Power Franchises; and (4) Administrative Measures.

The law fixes the maximum royalty to be paid for water power franchises at 3 francs per theoretical horse power per year, and provides for a decrease in the royalty in instances where storage reservoirs are built by private corporations. The full charge does not go into effect at once, but is gradually increased to the full amount at the end of six years, counting from the time when power is first generated. Franchises are limited to 80 years as a maximum. The Confederation itself may utilize any power site for national purposes, or any Canton for its own public requirements. No development not in accord with the broadest scheme for the rational development of a given stream will be authorized.

The law provides for the formation of co-operative organizations of franchise holders on a given power stream for the construction and maintenance of storage basins for their mutual benefit.

A public utility requiring to use a given power site may be granted the right of eminent domain, but private rights are carefully guarded by the requirement of the payment of full indemnity.

The natural beauty of streams is given due consideration, and power houses must not be made unsightly.

The possibility of monopoly of water power is entirely precluded as well as the charging of excessive rates for power, by provisions requiring power companies to make full reports to the government covering their fiscal affairs.

FRANCE.

Some measure of governmental regulation of water power development has been in force in France since the year 1851, and from time to time the control by the government has been rendered more complete. Water powers which may in the future serve for the electrification of the railways (which are all owned by the government) are held as inalienable national assets, and the development of others is based on government concessions, with rental charges.

The last law of which we have knowledge bears date of July 7, 1908. The law takes cognizance of the different economic relations of private plants and public plants. Private plants are those which develop power solely to serve the industrial needs of a particular establishment, and whose operation thus affects only private interests. These plants are subject to government regulation, and are established and maintained under a government authorization, which is limited to a 30-year period, subject however to renewal.

A public plant is that of a company generating power to sell or to operate any public utility. It operates under a franchise, and like other public utilities is subject to regulation by the proper Public Service Commission. It may exercise the right of eminent domain; and in dealing with it as to regulation of policy, fixing the amount of royalty to be paid, limiting the duration of the grant, the government seeks to "permit the realization of legitimate profits while restricting the operation to its essential character of a public service." We reproduce here the discussion of the details of the law by M. Louis Barthov, Minister of Public Works,

Post Offices and Telegraphs, and M. J. Caillaux, Minister of Finance, and submitted by them to the French Parliament.

Articles 1 and 2.

"After setting forth in Article 1 the principle of the classification of plants, the lawgives, in Article 2, the definitions of the two classes. It appeared that the true criterion should be sought in the purpose itself of the plant and not in the importance of the power which it utilizes. A paper mill or a flour mill, even though they be of considerable extent and utilize a large amount of power, remain none the less private establishments and the State grants to them the same advantages as to plants of more modest proportions but which are established with a view of serving industrial needs, and on occasion, the public services of an entire region.

"It will be noticed that Article 2 discriminates two different classes of public plants. Besides those which are founded especially with a view of selling energy to the public, there are those which have been created as an adjunct to a public service (railway or street-car, for example). Although they do not deal in energy, they partake of the character of public services, to which they are related. They are then in the first class of public plants.

Article 3.

"Article 3 maintains the present legislation with reference to private plants, modified only by an additional provision which puts an end to the unlimited franchise at present in force.

"The maximum duration which it has appeared advisable to assign to *authorizations* (the proper term to apply to private plants, the word *concession* being reserved to public plants) has been fixed at thirty years. It is a period of time long enough to assure to the proprietor the means of obtaining all necessary benefit from his authorization.

"The expiration of the grant should not, however, necessarily and automatically bring about the eviction of the proprietor. The state aims to reassume its liberty of action, but in the great majority of cases it will be entirely disposed to grant to the proprietor the benefit of a new authorization, either upon another basis or on the same conditions as in the past.

Article 4.

"Without creating distinctions absolutely unjustified, it is not possible to permit the existing plants to continue to exist under

the regime of unlimited franchises while those which are to be established will be subject to a limited grant. Article 4 fixes the duration of authorizations at present in force at thirty years, from the date of promulgation of the law. In this there is not any violation of the principle of non-retroactivity of laws, regarding the past; the article under discussion provides only for the future, that is to say for a period in which no right can have been established, in view of the essentially uncertain and precarious nature of the enjoyment which the proprietor could exercise in virtue of his title.

Article 5

"The utilization of water power involves, in the very nature of things, uncertainties and variations. In the first place, the quantity of water conceded, which is to be fixed taking account of the minimum flow of the stream so as to assure to the plant a minimum energy constant, may at times exceed the needs of the plant. On the other hand, the development does not necessarily absorb all the energy produced, and may leave a residue to be disposed of which it may be possible to use to advantage. It would be contrary to the principles of good administration to prevent the proprietor of a private plant from taking advantage of these resources and putting them at the disposition of the public. Article 5 aims to regulate the situation. It imposes on the proprietor of the plant the obligation of an administrative authorization. This formality seemed necessary to prevent the private plant transforming itself surreptitiously and irregularly into a public plant.

Article 6.

"Taking up the question of public plants, Article 6 decides that franchises shall be subject to the imposition of a tax and of a schedule of charges conforming to a determined model. There can, in fact, be no question of specifying in the law the detailed requirements to which the grantee must conform; it is to a type-regulation, drawn up under direction of the Council of State, that this duty should be left, as was done for the law of June 11, 1880, in the matter of street railways and by the law of June 15, 1906, in the matter of the distribution of energy.

"It seems useless to enter here into the details of the diverse questions which the schedule of typical charges will have to decide We will say only that there will be found there in the new law.

all that the water regulations in the present legislation provide for; namely as follows: (1) Precautions suitable for preventing as far as possible speculation and monopolization for which water power may offer opportunity. (2) Measures to be enacted for the effective utilization of the concession. (3) Conditions to be fulfilled for safeguarding the general interests (national defence, public health, navigation, food supply of populations, freedom of movement to fish, protection of landscapes, etc.) Besides these clauses of a general character, will be found provisions entirely special to the enterprise considered. (4) Duration; there can be no question here of proceeding by a general measure, and it is necessary to take account of circumstances peculiar to each enterprise (cost of installation, expense of development, probable profits of the enterprise), in such a way as to assign the proper duration to the period of amortization. (5) Reservations in the interest of public services. (6) Time beginning with which the sharing of the profits may be claimed by the State, and conditions of this sharing. (6) Restitutions in kind or damages in a manner to be stipulated for injured third parties. (8) Interval for execution of works, forfeits, etc., etc.

"It was not possible to impose on plants forming part of enterprises of public utility a regulation which would be in disagreement with the character of their charter, that is to say, the act which has declared of public utility the work to which they are related as accessories. Thus Article 6 provides for plants of a very exceptional nature, the elaboration of a special type, to be likewise submitted to the Council of State, and whose provisions will have to regulate the operation of the plant only in that which may not relate directly to the primary purpose of the latter.

Article 7.

"Article 7 formulates the principle of the relation of public plants to concessions of public works; it does not call for special comment, since it is limited to providing for the application in these circumstances of a very familiar system.

Article 8

"The new law has, in Article 8, extended to hydraulic plants the benefits of aqueduct and water supply easements which the laws of April 29, 1845, and July 11, 1847, had established in the sole interest of irrigation enterprises.

"However, the aqueduct easement has only been admitted when the water is carried underground; the establishment of canals open to the sky, of the importance of those which would have to be anticipated today, involves, not only a radical transformation of the locality, but even a veritable dispossession which could only be authorized in the forms and under the conditions provided in connection with expropriation.

"The regulations to be observed for the exercise of easements created by Article 8, and the manner of regulating indemnities are those admitted by the law of June 15, 1906, in the matter of the distribution of electric energy."

Articles 9 and 10..

"The relations of concessions of public plants to concessions of public works necessarily involved the taking by eminent domain of establishments thus created and their being taken over by the State at the termination of the concession. In formulating this double rule, Articles 9 and 10 simply draw the logical conclusion from the principle which makes of the grantee simply a temporary holder of the delegated authority of the State.

Article 11.

"As we have said above, plants exist which are public because they depend upon enterprises of public utility, of the character of which it is impossible not to make them partake. It has sometimes been questioned whether these concessions have the right to employ a part of their power in services other than those which were explicitly specified in the declaration of public utility. Article 11 has for its object to put an end to these uncertainties. There is in this simply a discerning administrative act. In permitting, for example, the plant which operates a street railway to sell energy in excess of the needs of the specified use, a double advantage is gained. On the one hand is rendered possible the sale to the public of quantities of energy which will generally be furnished at a rather low figure, since it is a question, for the power plant, if not of getting rid of waste, at least of realizing a profit on secondary power which might have been lost. On the other hand, the often important addition of these supplementary profits will permit the administration to demand and the grantee to accept conditions of exploitation more advantageous for the public.

Article 12.

"Article 12 determines the sphere of application of the law.

It might be asked *a priori* on what grounds this determination was necessary.

"In addition to canals for navigation constructed or conceded by the State, and water courses of the public domain, there are the rivers and streams navigable or suitable to flotation classed by Article 538 C. C., and whose nomenclature was fixed by the ordinance of July 10, 1835, modified by subsequent decrees of classification or reclassification. 'Although it was rendered in view of the application of the law of April 15, 1829, on fishing in streams,' we read in the Treatise on the Domaine of de Recy (No. 280), 'this ordinance is not the less considered as having a general application and as having determined the water courses which present in all respects the domanial character.'

"This interpretation, admitted by the doctrine, has been likewise accepted by jurisprudence, as is testified to by several decrees of the Council of State. 'Considering,' says one of these decisions, 'that it follows from the examination that the Gravelle branch is fed by the waters of the Marne, *which figures throughout its course in the Department of the Seine in the table of rivers navigable and suitable to flotation attached to the ordinance of July 10, 1835*, that no subsequent act having operated to the reclassification of this branch it should be considered as forming a part of the said river . . . .'

"On the other hand, the doctrine teaches that the public domain cannot be disclassified by non-usage; it is only when the domanial real property becomes unsuited to its purpose, incapable of serving for the use of all, that, the function ceasing, the privileges of domaniality cease with it. And the Council of State adds further to this information the high authority of its jurisprudence.

"The question may then pass for settled, and it would have been possible to act purely and simply under cover of the ordinance of 1835. The occasion appeared good, however, to repair an omission for which the authors of the law of April 8, 1898, were often reproached, and to put a stop by a categorical declaration to the doctrinal controversies to which certain formalistic minds have devoted and might again devote themselves. Besides, the fact must not be lost sight of that the establishment of power plants, with their impounding dams, may in certain cases have the effect

of diminishing the navigability or floatibility of a stream, and by this very fact may give more bitterness to the controversy. Also independently of modifications of greater or less importance which subsequent decrees have introduced in the ordinance of 1835, the public domain has been increased, at different times, by water courses and canals constructed or repurchased, relative to which no act recitfying the ordinance of 1835 has officially intervened.

"We are convinced that the state of navigability of water courses described in the ordinance of 1835, in consequence of a very complete and minute investigation, has undergone only insignificant changes; in any case, the State has for more than seventy years constantly administered as dependencies of the public domain *all* water courses coming under this classification; it has collected royalties of every sort (concessions for the use of water, farming out of fishing rights, riparian rights, etc. . . . .); and never has a protest from the owner of abutting property come to trouble it in the enjoyment of its rights. The State appears then to have grounds for considering that the provisions of Article 12 of the draft, solely designed to safeguard the uncontested rights of the community, cannot injure any private interest. We have none the less on that account taken care, by excess of scruples, to conserve the situation of certain adjoining property owners (very rare, assuredly, if they so much as exist) who might in good faith have exercised on some streams whose navigability might have varied since 1835, the rights which the law recognizes as belonging to owners of land abutting water-courses not navigable or floatable.

"To this end the last paragraph of Article 12 grants to the interested parties the option of having established, within the interval of one year after the passage of the law, the fact that the present regulation of the water-course over which they pretend to have rights no longer corresponds with the state of affairs resulting from the provisions of the ordinance of 1835. This period having expired, if no opposition has been produced, or if the action entered by the interested parties has been decided to be unfounded, the presumption of Article 12 will become final, and this without indemnity for the abutting property owner.

Article 13.

"The new law—and this is the import of Article 13—does not aim to be substituted for that of April 8, 1898, as far as relates to

the fixing of domanial royalties. However, the administration, in the elaboration of the new regulation which it is to prepare for the application of Article 44 of the law of 1898, will proceed from the proposed distinction between private plants and public plants. These last may benefit by certain reductions in royalties in favor of the part of their concession relating to public services. Further, as the law of April 8, 1898, is not applicable to the canals of the public domain, it has seemed necessary to explicitly extend to these last the provisions of Article 44, which fixes the principle of the royalties to be paid to the treasury.

Articles 14 and 15.

"Article 14, which provides for the issuance of public administrative orders for the application of the law, and Article 15, a purely formal clause, call for no comment.

"Such is, in its essential features, the draft of the law which we have thought proper to submit to your consideration, with a view to regulating in a manner as simple as possible the standing in law of hydraulic plants established on canals and water courses of the public domain.

"We count upon the co-operation of the Parliament to aid us in realizing a legislative reform which cannot fail to contribute in the most desirable fashion to the development of the hydro-electric industries of our country."

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